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DEARTH OF SCIENCE TEACHERS IN SCHOOLS

AT the Birmingham meeting of the British Association for the Advancement of Science, a special evening meeting was arranged by the Division for Social and International Relations of Science to discuss the question of the shortage of science teachers. The importance and urgency of this problem was amply demonstrated by the numbers attending, despite other attractions arranged for the same evening. This matter was raised in January last at a meeting of the Division, when it was agreed that, since the shortage is one which clearly threatens to reduce the output of scientific workers to a level which may have serious results for the nation, a sub-committee be appointed: its job was to prepare information concerning the dearth of science teachers, and this information was set out in a document for discussion at Birmingham.

It is well to be quite clear about the purpose of the discussion. Even a preliminary study of the problem is sufficient to show its complications and difficulties. How, for example, can the shortage of science teachers be separated from the shortage of other teachers? How does one separate science graduates from graduates in arts? Not always is there a clear, sharp line between the two: indeed, there are occasions when they are indistinguishable. We are glad to note that the sub-committee's document did not avoid that issue, and that it showed the danger of doing something hurriedly which might so easily militate against doing something of lasting value. With that in mind, the chairman of the sub-committee, Mr. Ritchie Calder, who was also chairman of the meeting at Birmingham, made clear that there was no intention of passing resolutions and making specific pronouncements at this stage. The object of the discussion, he pointed out, was two-fold: it was to focus attention on the shortage, and to gather further suggestions which might help the sub-committee and the British Association if it were found possible to recommend specific action.

There can be no doubt about the shortage. Irrefutable evidence exists in technical colleges, grammar and modern schools; it has been set out in reports of university appointments committees, in the published results of inquiries, and in the document discussed at Birmingham. The important questions to be examined, therefore, are: What are the causes of the shortage, and what can be done about them?

Both these questions were dealt with in the document before the Birmingham meeting and in the discussion itself. As to causes, it is clear that the salary paid to science teachers is insufficient when there is competition for people trained in science between the teaching profession, industry and government departments. This has been made abundantly clear in correspondence in professional and other journals, and should be taken fully into account by the Burnham committees which are at present negotiating new salary scales for teachers in Great

Britain. Other causes may well be found in the immobility of the teaching profession, which is a result of housing shortage, and in the conditions and prospects of science teachers. In this connexion, reference was made by the sub-committee, in preparing material for the Birmingham discussion, to the appointment of science teachers to headships and directorships of education; it would be interesting to know how many such appointments are secured by science teachers as compared with arts teachers, for whom these posts seem traditionally to be reserved.

But there is, of course, a cause perhaps even more potent than all these. Everyone knows that, before the War, advertisements attracted large numbers of applicants, not only in the teaching profession, but also in many other spheres of employment. Now the response is small, and sometimes, indeed, non-existent. With this in mind, the sub-committee was right in emphasizing the point that in the pre-War years we lived under a contracting economy which was accompanied by unemployment. The opposite is now the case. We live under an expanding economy which is accompanied by man-power shortage. Nor would it be wise to assume that the man-power problem is merely a very temporary phase. Further, since science graduates are so much in demand in schools, in industry and in government departments, it seems inevitable that close attention must be given to the spread of available scientific workers so that the demand in all these fields may be satisfied as equitably as possible. That may mean that the teaching profession will not be able to look forward with any high confidence to recruiting so large a proportion of graduates with high honours in science as it did in times of a contracting economy. This is by no means palatable, since the teaching profession ought to recruit the best; nevertheless, it is a matter which must be faced and examined.

All these points were before the meeting at Birmingham, when the discussion was opened by Sir Fred Clarke, formerly professor of education and director of the Institute of Education, University of London, Sir Arthur Fleming, director and manager, Research and Education Department, Metropolitan-Vickers Electrical Co., Ltd., and Dr. A. W. Barton, headmaster-elect of the City of London School. The last-named, as a headmaster, had no difficulty in showing how acute the shortage of science teachers is and how far-reaching its effects may be. Sir Fred Clarke, too, showed that there is no doubt about the shortage, but he suggested that the problem, with all the careful approach it needs, could not be solved by immediate sweeping change. In his usual lucid and thoughtful way, he argued for a short- and a long-term policy. Particularly he showed the dangers of approaching the salary question merely from the angle of shortages. If that were done, he indicated other ranges of the teaching profession where shortages were acute, and showed that hurried adjustments to remedy those shortages might go far towards the destruction of salary structure.

A great deal of weight has often been placed upon the advantages which accrue to science graduates who go over to industry; but it was here that Sir Arthur Fleming, out of his long experience, was able to be more precise than is sometimes the case when this matter is discussed. Salaries are, of course, attractive, he said, when the science graduate has proved his worth; but they are not necessarily attractive before that has been done. Moreover, compared with those in the teaching profession, holidays are short and security of tenure such as exists in the teaching profession does not exist.

The fruitfulness of the discussion will depend on the way it is followed up. It is hoped that contributors to it will forward not only the suggestions they then made, but also any new evidence and ideas, so that a decision may be reached as to any action which the Association can finally take to solve this urgent and vital problem. The Association has done well to provide a platform for focusing attention on the subject, and is giving a valuable demonstration of the fundamentals of scientific method in its careful approach.

THE PHILOSOPHY OF BOTANY

The Natural Philosophy of Plant Form

By Dr. Agnes Arber. Pp. xiv+247. (Cambridge: At the University Press, 1950.) 25*s*. net.

DR. AGNES ARBER has long been held in high esteem among botanists for her books on plant morphology and on the history of botany, which have been models of careful investigation, clear thinking, lucid expression and admirable illustration. She has now given us one of the most important botanical works of the present century, which few students or teachers of the plant sciences can afford to neglect. Everyone concerned with the study of plants holds some view as to the relationship of their parts and structures; but the philosophical basis of such views is seldom realized. Few, if any, British authors for more than a century have discussed the fundamental concepts and the mode of reasoning which have led men to generalizations on plant-form, and confusion of thought on these matters has been widespread. This confusion has arisen through the persistent attempts, made during the past eighty years, to blend the pre-Darwinian philosophy of plant-form, a purely intellectual concept, with the materialistic and objective outlook of the doctrine of evolution. Describing the source of this error, Dr. Arber writes, "by a feat of legerdemain, which seems to have passed almost unnoticed, the Ancestral Plant was substituted for the Archetypal Plant, and those characters which had, with reason, been attributed to the mental conception of the archetype, were, without further justification, assumed to have been proven for an actual, historically existent ancestor". The results of this fallacy have become so deeply embedded in the minds of many botanists of the present day that they often fail to understand both the achievements and merits of the old or classical morphology, and also the logical position of those who are trying to provide an interpretation of plant-form from the point of view of evolution. It is seldom realized that we know nothing about the ancestors of the angiosperms, and have no objective information relating to the structure of their flowers. Most of the dis-

cussions of floral evolution are therefore entirely fictitious.

The present work places the long and valuable study of plant form in its true perspective. The doctrine of evolution finds little or no place in the author's development of her subject. "To arrive at the fullest understanding of any individual plant form, we have," she says, "first to realize it accurately by means of sensuous perception, secondly, to get the completest possible picture of it with the mind's eye . . . and thirdly, to advance beyond this representation so as to grasp its underlying and surrounding context of significance, and to see it in its living aspect and in its relation to other forms." Believing that repeated scrutiny of the embryonic phases of biology is essential to its progress, she traces the origin and development of morphological thought from the time of Aristotle to the present day. The comparative study of plant-form requires a frame of reference in terms of which the manifold varieties of shape and structure may be described and classified. The required standard of comparison is provided by the concept of the organisation type.

The development of this concept by Goethe and others is explained, and Dr. Arber shows that, to Goethe, the *Urpflanze* was a mental concept, which carried no phylogenetic implications, and did not suggest any notion of an ancestral stock. This archetype was visualized as an axis bearing a series of lateral appendages of varying form, but all referable to an abstract concept which was called the leaf (*Blatt*), but for which the term phyllome is preferable. The axis bore one (or more) roots. The phyllome varies so much in form in the cotyledons, bud-scales, foliage leaves, bracts and the parts of the flower, that morphologists, while generally regarding it as an easily recognized category, have not attempted to define it. In her treatment of the concept of leaf organisation, Mrs. Arber makes a very important new advance by the development of the thesis that the leaf is to be regarded as a partial shoot, with an urge towards whole shoot characters. "The different kinds of phyllomes are not regarded as manifestations of, or deviations from, one type, but are treated as parallel members, whose characteristics depend upon the fact that they are all incomplete shoots." Much interesting evidence, illustrated by figures, is brought forward in support of this view, and a modification of her well-known theory of the nature of the leaf in many monocotyledons is proposed. It is interesting to find that this new concept of the leaf closely resembles the views that have been developed in the 'new morphology', based on evolutionary evidence.

The new interpretation of the phyllome, or leaf, simplifies the morphological treatment of repetitive growth, such as is seen in compound leaves; it leads to the concept of parallelism in organisation and configuration between different phases of the plant body. The development of this idea, as applied to inflorescences and flowers, provides a mode of approach, simpler and more satisfactory than that of Troll, to the reproductive branches of plants like the Compositæ and Umbelliferæ. Wilhelm Troll, as a rigid typologist, had to face considerable difficulties in dealing with structures in which an inflorescence of inflorescences has the general form of a single flower, and those who were not well trained in metaphysics found his *Gestalt* theory very difficult to comprehend. Many readers will be grateful to Dr. Arber for her explanation and illustration of Troll's views.

The concluding chapter, on the interpretation of plant morphology, is of particular interest, for it illustrates very clearly the author's approach to her subject and its difference from the materialistic point of view common among botanists to-day. Starting from Aristotle's investigation of the nature of causation, she examines the relationship between the mechanistic and teleological interpretations of structure. "We can free ourselves," she remarks, "from the crippling effects of the antithesis between teleology and mechanism, by recognizing that they are not inherently antagonistic but that they represent the organism *under two different attributes*—the physico-chemical attribute, and the attribute of inherent directiveness."

It is difficult to give an adequate account of Dr. Arber's philosophy and of her treatment of the work of other thinkers. She helps her readers to follow the argument by the provision of many excellent figures; but, nevertheless, many botanists will find themselves in an unfamiliar world of thought. They may have been interested in experimental morphology, or in other studies of plant-form, which have originated in the idea of evolution. Such considerations, however, belong to a materialistic philosophy, which does not enter into the system of ideas developed by the author.

When the significance of the concepts of the classical morphology have been understood, the reader will be better prepared to consider alternative methods of thinking about plant-form. For example, many of the differences in the shape and structure of plants may have come about through the operation of internal and external factors on a race of organisms in the course of many generations. The relationship between the resulting forms, though originally envisaged as a concept, is an objective connexion, entirely independent of the exercise of man's mental powers. This connexion is demonstrated by the methods of the historian rather than by those of the philosopher.

From this point of view it may be possible to establish a new frame of reference for the study of form, based on a knowledge of the changes that have occurred during past ages. Such a frame of reference seems to be a valid alternative to that founded on the intellectual concept of the ideal plant. Its construction and use involve not only the consideration of the geological records, but also the study of all the biological factors affecting the life and growth of plants.

While some progress has been made in the formulation of this new morphology, it is still incomplete. But even when developed into a philosophic system, it will not invalidate the work of those who have followed the classical tradition. An analogy may make this clear. A comparative study of the great cities of the world may be made by comparing each of them with the plan of an ideal city, as conceived in the mind. An alternative method would be to trace and compare the way in which each has grown from a primitive settlement. The two methods constitute distinct modes of approach to the same problem. It would be a mistake to suppose that Dr. Arber's treatment of plant-form is diminished in value because of its abstract character. It will be long before any materialistic or new system is produced which is comparable with the body of thought that Mrs. Arber has now put before us.

H. Hamshaw Thomas

FOR THE UNDERSTANDING OF SCIENCE

The Growth of Scientific Ideas

By Dr. William P. D. Wightman. Pp. xii+495+8 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1950.) 25*s*. net.

THIS is an important and valuable work, and its purpose is well outlined in the preface. Dr. W. P. D. Wightman, referring to two great thinkers of the recent past—R. G. Collingwood and A. N. Whitehead—writes: "In their several ways they have, I believe, emphasised the two-fold nature of historical fact, namely, that every standpoint is what it is by virtue of its origin from the past and its urge towards the future". This consciousness of the importance of evolution in a context of associated ideas, which runs through the book, places it in a special position among the various histories of science. It is a guide to the study of the development of scientific thought as illustrated by a few dominant ideas. In consequence, the author is at great pains to reveal problems as they appeared to leading thinkers of each age, "to describe in outline the nature of the solutions attempted, and to assess (in the light of later modification) the proportion of essential truth to psychological imagery . . . In this way, science becomes revealed as a *struggle*, a struggle no less charged with humanistic value than the struggle for political liberty or national expression; in a word, as a branch of *Litteræ Humaniores*." A great merit in the method of treatment is the frequency of quotations from appropriate original sources, whereby a sense of historical actuality may be acquired by such controversies as phlogiston, caloric or animal spirits.

At the outset the author emphasizes the importance of recognizing the dependence of Greece on earlier civilizations—"we are in no doubt that *science* was born with infinite pains and in many places, neither by the happy inspiration of one man, nor at any clearly defined epoch". Greek thought, however, differed from all that had gone before in both generality and rigour. "Science is, among other things, the generalization of perceptual experience by means of adequate concepts; the concepts grow with the experience; history is the record of their growth: philosophy, among other things, the critique of their adequacy." The first chapter, "The Birth of Scientific Ideas", from which these quotations are taken, forms a comprehensive prologue to the whole book.

Dr. Wightman has quite naturally divided his work into two parts—"Matter and Motion" and "Nature and Life". The first part (which contains twenty-four of the total thirty-three chapters) deals with the scientific ideas leading up to the Copernican Revolution and later the Newtonian, and ends with a masterly survey of the power of physical analysis. The second part leads to the Darwinian Revolution, and the final paragraph is an indication of the author's faith—"'In my end is my beginning'. In the growth of ideas these words are charged with a new ambiguity; for, if the history of science teaches us anything, it is that only to those who ask the right questions are any answers vouchsafed. Not even to them are these answers the end of the quest, but only an enlargement and a refining of the question. If we look back to see whence we have come, we may better set the course on which we are to go. And in frequent converse with those who have brought us where we are, we enjoy in Whitehead's immortal words 'the habitual vision of greatness', without which the Conquest of Nature must spell the Defeat of Man."

The illustrations are well chosen and well produced, and the value of the work is enhanced by a list of sources at appropriate intervals throughout as well as a general bibliography at the end. A short "Chronology" and a separate name and a subject index are in keeping with the author's characteristic attention to detail.

THE SCIENCE OF METALS

Progress in Metal Physics

Edited by Dr. Bruce Chalmers. Vol. 1. Pp. viii+401. (London: Butterworth's Scientific Publications, Ltd.; New York: Interscience Publishers, Inc., 1949.) 45*s*. net.

"THE purpose of this volume, which is to be the first of an annual series, is to present authoritative reviews of the present state of knowledge in specialized aspects of the field that includes both physical metallurgy and metal physics." The need for a publication of this kind has long been apparent, and the editor and publisher are to be congratulated on taking a step which has been discussed and shirked by many bodies. The decision to make the book a series of reviews, and not a mere list of abstracts, is to be commended, and the result is a volume which will be of great value to all those concerned with the science of metals. The book is well produced, with pleasantly large type and clear diagrams; but the printers should obtain a proper fount of Greek characters.

The first review, by G. V. Raynor, on "Progress in the Theory of Alloys", is clear and well written, and covers a wide field rather uncritically. It is unfortunate that the author should use the symbol k for the wave number $1/\lambda$, when nearly all books use this symbol for the quantity $2\pi/\lambda$, while the statement at the top of p. 25, which identifies the direction of motion of the electron with that of the wave-number, is incorrect for electrons in periodic fields. The author also fails to point out that the high co-ordination numbers which certain authors claim for some intermetallic compounds result entirely from including neighbours at different distances, and that if comparison is to be made with normal metals the same policy must be adopted, in which case the co-ordination number for the body-centred cubic structure is $8+6=14$.

The review by A. H. Cottrell on "Theory of Dislocations" is sound, but could be made more interesting. Some readers will, perhaps, be left with the impression that the theory of dislocations is being developed too much by arbitrary assumption, when the real need is for direct experimental evidence of the underlying idea. The review by R. King and B. Chalmers on "Crystal Boundaries" is an interesting and suggestive study of a subject of great importance. G. C. Smith's review of "Age-Hardening of Metals" is less satisfactory; it could well be reduced to one-half of its present length, and most readers will be compelled to prepare their own summaries before the subject-matter is appreciated. The papers by E. H. Bucknell and W. Stevens on "Hardening Response of Steels", and by T. Ll. Richards on "Preferred Orientations in Non-Ferrous Metals", are interesting, but would both profit by the inclusion

of diagrams to show the atomic processes involved. It is significant to notice how, in comparing the effects of different elements in steel, little or no attention is paid to the atomic as contrasted with the weight percentages of the added elements. The final review, by A. D. Le Claire on "Diffusion of Metals in Metals", deals with a subject of extreme importance, which has been rather neglected in Great Britain. The volume thus covers a wide range and will interest many readers.

W. Hume-Rothery

THE FISCHER–TROPSCH PROCESS

The Technology of the Fischer–Tropsch Process
By B. H. Weil and J. C. Lane. Pp. xiii+248. (London: Constable and Co., Ltd., 1949.) 22*s*. 6*d*. net.

Die Kohlenwasserstoff-Synthese nach Fischer–Tropsch
Von Dr. Franz Kainer. Pp. vii+322. (Berlin, Göttingen und Heidelberg: Springer-Verlag, 1950.) 39.60 D. marks.

THE technical feasibility of converting coal into liquid fuels, that is, aviation spirit and diesel oils, by the Fischer–Tropsch process, in which a mixture of carbon monoxide and hydrogen prepared from coke and steam is converted catalytically at low pressure into mixtures of hydrocarbons and oxygenated products, has already been demonstrated in Europe. The Fischer–Tropsch process was put into commercial operation in Germany in 1936, and underwent a rapid development during the Second World War when Fischer–Tropsch products were used for eking out deficiencies of chemical materials of natural origin other than liquid fuels.

At the present time intensive research on many aspects of the Fischer–Tropsch process is being pursued in the United States, and the construction of several commercial plants has been projected. In the book by B. H. Weil and J. C. Lane, the American authors have reduced to coherence some three thousand articles, reports and patents on the Fischer–Tropsch process. The work contains twenty chapters, each with a bibliography, and three appendixes. The first five chapters deal with synthesis gas, its preparation from coal and from natural gas, and its purification from sulphur compounds. Four chapters are devoted to reaction mechanisms and catalysts and are followed by seven further chapters on the main products (gaseous fuels, gasoline, diesel oil, waxes, lubricants) and the by-products (fatty acids, soaps and detergents, alcohols, etc.). The concluding four chapters on the economics of the process in the United States will be of less interest to non-American readers. The three appendixes containing extensive and classified lists of patents, government-released reports and recent articles and papers (to 1946) constitute an extremely useful directory to original sources of information. This book can be recommended as an excellent introduction to the subject for the general reader, and as a reference text for anyone actively working in the field.

The second book, by F. Kainer, covers much the same ground with the difference of emphasis which would be expected from a German author. While the text contains more information drawn from original sources in patents and journals than Weil and Lane have thought fit to include, it is an ill-digested production, and appears to have been put together hastily from a none-too-complete card-index bibliography of the subject. The author does not seem to have had access to B.I.O.S., C.I.O.S. and similar reports on aspects of German Fischer–Tropsch technology, which contain a vast amount of important matter. Numerous obvious errors have occurred in transcription, especially in the names of British workers.

This treatise is a poor example of a familiar type of compilation. To make a book of this kind, a kind which has a real, if limited, use, requires little critical ability. The user only expects that the bibliographical references to original sources will allow him to assemble for himself the information he needs, and which he can evaluate for his own purposes. To this requirement Kainer's book is inadequate.

E. A. Coulson

HUMAN GENETICS

Principles of Human Genetics
By Curt Stern. (Series of Biology Texts.) Pp. xi+617. (San Francisco: W. H. Freeman and Co., 1949.) 5.50 dollars.

THIS text-book deserves to attain a foremost place in university courses of genetics and anthropology. Its merits are many, and it reveals its author as a gifted teacher of the subject. It has arrived at a time when a reliable, balanced and well-documented guide is badly needed by the student of human biology. Prof. Stern offers the book as an introduction to genetics, with man as the organism by which to illustrate the basic principles of genetics. In this respect the book amply fulfils its purpose. There are particularly valuable discussions on the relation between heredity and the environment, multifactor inheritance, mutation and natural selection. The artificial induction of mutation by radiation has become of great, if rather melancholy, importance in human genetics, and the consideration given to this topic here is very timely. Descriptions of the pathological manifestations of hereditary abnormalities have been presented with discrimination.

The book is opportune also in that a large proportion is devoted to an exposition of the more controversial themes in human genetics, those relating to human evolution and differentiation. Prof. Stern handles carefully, and calmly, the modest body of data available at present on such questions of racial genetics as race 'purity' and 'superiority', Negro–White miscegenation and eugenics. In view of the treatment such questions have sometimes received, even at the hands of specialists in genetics in much bulkier tomes, one cannot be too grateful for the guidance the student will derive from this work. Here, one point may be made. Dobzhansky's view that the apparently large morphological differences between fossil Hominidæ (of generic order according to some) do not constitute a bar to their inclusion in one polytypic species deserves special consideration seeing that reference is made to Gates's diametrically opposed, and generally unaccepted, opinion.

The methods used in human genetics are well displayed in the questions set out at the end of most of the more technical chapters. J. S. Weiner

Organic Chemistry

By Prof. G. Bryant Bachman. (International Chemical Series.) Pp. x+432. (New York and London: McGraw-Hill Book Co., Inc., 1949.) 36*s*. 6*d*.

THIS introduction to organic chemistry is designed as a one-year course for non-chemistry majors in the United States. In Great Britain it could be used by students taking subsidiary chemistry; but more particularly it appears eminently suitable for students taking the general degree in chemistry.

In thirty chapters, Prof. G. B. Bachman provides a lucid survey of organic chemistry, based on the electronic theory of valency, and, without overloading with detail, emphasis is placed on the application of organic compounds to everyday living. The International Union of Chemistry system of naming organic compounds is described, together with notes on pronunciation, which with the probable exception of that for -yl (as in methyl and devil) would find acceptance in Great Britain. Then follow chapters on systematic aliphatic and aromatic chemistry. Optical isomerism is used to introduce an outline of the mechanisms of aliphatic substitution and addition reactions, while the aromatic section is preceded by a chapter on resonance and a brief account of aromatic substitution. Heterocyclic compounds are not neglected in an admirable survey, although this perpetuates the misleading concept of the superaromaticity of furan. There are also excellent chapters on the chemistry of body processes, chemical constitution and colour, chemical constitution and physiological action, and on synthetic polymers. To each chapter is appended sets of exercises and problems.

The production is well up to the standard of the International Chemical Series, though some of the illustrations are rather trivial. S. H. HARPER

Journal of the Institute of Metals

Editor: Lieut.-Colonel S. C. Guillan; Assistant Editor, Major W. G. Askew. Vol. 74, 1948. Pp. xxxviii+804+57 plates. (London: Institute of Metals, 1948.) £3.

THIS volume contains three special lectures and twenty-eight papers, 166 pages of correspondence and discussion, and an index, and one must say immediately that, in every way, it upholds the high standard that one has learned in the past to expect from the Institute of Metals. The Autumn Lecture, by Prof. G. Wesley Austin, on "The Metallurgical Resources of Scotland", the presidential address by Sir Arthur Smouth, in which the history of the Institute is surveyed and its future discussed, and the May Lecture by Prof. A. O. Rankine on "The Search for Minerals by Physical Methods", provide a change from the twenty-eight specialized scientific and technological papers. The latter, which are concerned in the main with metallography, the industrial aspects of the Institute's interests, theoretical metallurgy, and the common ground between the metallurgist and the engineer, add substantially to knowledge in all these fields.

It is, perhaps, invidious to choose for special mention any specific papers where the general level is so high, and any such choice must inevitably reflect the particular interests of the reviewer. To him, however, the papers on "The Equilibrium and Kinetics of Order-Disorder Transformations in Alloys", by Prof. Borelius; on "The Calculation of Loads Involved in Metal Strip Rolling", by Cook and Larke; on "The Determination of the Elastic Moduli of Aluminium Alloys in Tension and Compression", by Grover, Munro and Chalmers; on "The Measurement of the Damping Capacity of Metals in Torsional Vibration", by Cottell, Entwistle and Thompson; on "The Relationship between Stress and Strain for Homogeneous Deformation", by Voce; and on "The Solubility of Hydrogen in Liquid and Solid Aluminium", by Ransley and Neufeld, indicate at any rate some of the particularly interesting papers presented. In addition to these, and as would be expected from the history of the Institute, constitutional work on alloys of high standard is presented in many systems. Further, the industrial interests of the Institute are, directly or indirectly, reflected in many papers, several of which refer to the cracking of alloys, particularly those of aluminium, at temperatures in the region of the solidus.

The work of the editor and of all those concerned with the preparation of the volume deserves the highest praise.

Molybdenum: Steels, Irons, Alloys

By R. S. Archer, J. Z. Briggs and C. M. Loeb, Jr. Pp. xii+394. (London: Climax Molybdenum Co. of Europe, Ltd., 1948.) Free.

THE importance of molybdenum as an essential ingredient of many alloy steels and cast irons is now so well established as to need no stressing. A volume, therefore, which contains a full discussion of the effects of the addition of this element clearly serves a useful purpose. In the book under review, the effects of molybdenum on the structure and properties, both at normal and elevated temperatures, together with the manner in which it may be introduced, are fully discussed. A final chapter dealing with the use of this element in a variety of alloys for special purposes illustrates the unexpectedly wide range of its importance. In magnetic materials, in electronic devices, as elements for thermocouples, in alloys of constant elastic modulus, and even in materials for the dental profession, molybdenum-containing materials find application. There are indications that the compilers have been, perhaps, somewhat enthusiastic in their recommendations of these materials, but the volume is none the less of real value.

Biological Actions of Sex Hormones

By Dr. Harold Burrows. Second edition, entirely revised and reset. Pp. xiii+615. (Cambridge: At the University Press, 1949.) 42*s*. net.

IT is only four years since the first edition of Dr. Burrows's "Biological Actions of Sex Hormones" appeared (*Nature*, 159, 182; 1947). The purpose of the book was to provide a comprehensive survey of literature on the sex-hormones up to the period 1941–42. It has now been amended by the inclusion of fresh material, references being made to some papers published as late as 1947. Its emphasis, however, is still mainly on pre-war work, and Dr. Burrows has not cited several valuable recent reviews on such subjects as ovulation and adreno-gonadal relationships. Nor does he mention the Laurentian Conference discussions or the reviews in *Vitamins and Hormones*.

Shortcomings, however, are inevitable in all books which set out to review a vast subject. The reader has enough reason to be grateful to Dr. Burrows for the work he has done.

INDUSTRIAL APPLICATION OF ATOMIC ENERGY

ONE session of the recent meeting at Birmingham of the British Association, held in the Great Hall of the University, was devoted to an account of industrial applications of atomic energy. The session was opened with a paper by Sir John Cockcroft on the problems and prospects of nuclear power development. The paper covered much of the same ground as the discussions in the World Power Conference; but more information was given about the development work proceeding at the Atomic Energy Research Establishment, Harwell. One of the advantages of the second Harwell pile, the B.E.P.O., is that it can be used at the same time for experiments in nuclear physics, solid-state physics, radiation chemistry and nuclear engineering development. One of the most important problems in nuclear power development is to be able to transfer the heat developed in the uranium fuel elements, safely and efficiently, to a conventional power unit, whether it be a steam boiler followed by a turbo-generator station, or in the long run, perhaps, a gas turbine.

The difficulties arise, Sir John pointed out, from the intense radioactivity developed in the fuel elements, which must not be allowed to leak into the heat transfer fluid, the reactive character of the uranium metal—which oxidizes only too readily, given the opportunity—and the effects of neutron bombardment on the mechanical stability of the fuel elements. The uranium fuel elements have to be 'canned' with a metal of low neutron absorption to overcome these difficulties, and the welds of the can must remain free from pinholes during the long working life of the fuel elements. The B.E.P.O. contains 16,000 fuel elements, and during its two years of operation the working temperature and, with it, the power-level, has been steadily raised, while fuel elements are withdrawn at intervals and examined by X-rays to study any incipient troubles. Metallurgical development has gone along with this, and improved fuel elements have been developed which will allow substantially higher temperatures—of the order of 300° C.—to be reached; and with this the operating power-level should be increased to about 10,000 kilowatts. In order to develop power efficiently, it would be desirable to operate at boiler temperatures similar to those now used in British Electricity Authority power stations, namely, 455° C.; work is therefore proceeding on the metallurgy of beryllium and zirconium, which are promising canning materials for these higher temperatures. The metallurgy of these elements is in an early stage of development, so that some time may be required for the necessary development programme. It will be possible to use the B.E.P.O. to test these high-temperature fuel elements as they come from the laboratories of the Harwell metallurgy division.

Another important problem is the stability of constructional materials and moderators used in the power reactors. Mr. T. M. Fry gave an account of the effects of neutron bombardment on the physical properties of several substances of interest to pure physics. Similar studies are proceeding on the technologically important materials as part of a co-operative programme with the Chalk River Atomic Energy Establishment. The high flux of the Chalk River pile reduces materially the time required for such investigations.

Three new types of power reactors are under consideration. The first is a development of a reactor of the B.E.P.O. type burning natural uranium as its fuel elements. Reactors of this type are near breeders in that the primary fuel element, uranium-235, is partially replaced by the secondary fuel, plutonium, with fission products as a radioactive ash which acts as a 'poison' to the reaction. The 'burning time' of the fuel elements will depend very much on the degree of such poisoning. A hypothetical reactor containing 200 tons of uranium metal and developing 200 megawatts of heat might have a fuel burning-time of between ten and thirty years before its reactivity fell to unity and the chain reaction ceased. Experience is being gained which will decide this point. The burning-time is obviously important since it determines the fuel requirements of such a system, and with it the fuel and therefore the power costs. Burning times of ten and thirty years would require an annual consumption of about 1,800 and 600 tons of uranium metal respectively to supply the power needs of the United Kingdom alone, and such a system could only be supported if the extraction of uranium from low-grade ores could be carried out at reasonable cost. Experimental work on extraction from low-grade ores is now proceeding at Harwell and at the Chemical Research Laboratory at Teddington.

It will not be possible to decide on the feasibility of nuclear power or to give any good estimate of its costs until pilot power-producers are built and operated. Very rough figures of the capital and fuel costs of a modern British Electricity Authority power station compare not unfavourably with guessed figures of the additional cost of the nuclear boiler and limits of cost of uranium fuel elements, assuming refuelling times of ten and thirty years respectively. These figures do no more than show that nuclear power costs will be likely to be of the same general order as conventional power costs, and that it is worth while to proceed with development work to determine these costs more accurately. Pilot plants based on natural uranium fuel elements would be bulky and costly. It is therefore desirable to reduce the scale of pilot power-producers by using enriched uranium fuel elements; feasibility and design studies of such a reactor are now being carried out at Harwell in collaboration with an industrial organisation. Construction will probably take three to five years after approval is given to the project.

Design studies are also being carried out on an experimental breeder reactor, one of which is already under construction in the United States.

This experimental and development programme is likely to occupy the next decade. If the development work is successful, nuclear power would be likely to start in specialized applications where fuel costs are less important, and then to spread gradually to more conventional power stations. British fuel reserves have been estimated as lasting from 200 to 300 years by Dr. A. Parker, director of the Fuel Research Station, Greenwich; power consumption is increasing by 10 per cent a year and there is increasing competition with the chemical engineering industry for

fuel. New power sources are therefore of considerable long-term importance, though other potentialities should be pursued in addition to nuclear power.

Dr. H. Seligman spoke next on the immediate benefits which atomic piles are providing, in particular the industrial use of radioactive isotopes. The expansion of radioisotope production at Harwell has been so rapid that practically all the surplus neutron flux in B.E.P.O. is now used, and a limit to the supply of radioactive materials requiring high flux—such as radiographic sources—may very soon be reached, unless measures are taken to increase the available neutrons.

A number of industrial applications were described. The use of thickness gauges using a β-emitter as a source on one side of a continually produced strip and a detector on the other is extending from the paper, plastic and cardboard mills to steel mills, and for this purpose the fission product strontium-90, which emits an energetic β-ray, is required. For this purpose facilities for the separation of substantial quantities of fission products are being installed at Harwell. At present only pilot-scale facilities are operating.

'Static eliminators' containing thallium-204, for the dissipation of undesirable electric charges, are being made experimentally at Harwell and lent to firms for trial. It is thought that in six months or so static eliminators will be available commercially to satisfy all industrial demands.

Other applications make use of the extremely sensitive methods of detecting radioactive elements. For example, radioactive sodium is being used to trace a suspected leak from a lake containing fifty million gallons of water to coal pits. Radioactive bromine contained in an organic compound has been used to check the ventilation system of a factory; radioactive sodium has been used to check the efficiency of mixing of one gram of a vitamin in five tons of cattle food.

Radioactive cobalt has been used in several pipe-line operations. At the Gasification Research Station the intersection of two borings in a coal seam was facilitated by inserting a 500-millicurie cobalt source in one seam and a detector in the other. The clearing of long pipe-lines is assisted by making the scrubber radioactive, so that its position can be determined in case of blockages.

These are a few representative applications out of a hundred or so which the Atomic Energy Research Establishment has developed or helped to develop for industry. It is believed that much more use of isotopes could be made in industry, and it is hoped to start at Harwell in the early part of 1951 a training school in their applications.

Mr. W. S. Eastwood described the application of isotopes to radiography in industry. The Harwell pile is now producing γ-emitting sources having conveniently long half-lives—60 days to 5 years—and a wide range of γ-ray energies, so that the energy most suitable for the job can be chosen. The isotopes in most demand are radiocobalt (half-life 5·3 years; energy 1·1, 1·3 MeV.); radioiridium (half-life 70 days; energy 0·30, 0·47, 0·60 MeV.) and radio-tantalum (half-life 120 days; energy 0·15, 0·22, 1·13, 1·22 MeV.). In the future, sources of europium (half-life 5 years; energy 0·12, 0·34, 0·41, 1·2 MeV.); cerium (half-life 275 days; energy 1·25, 0·22 MeV.) will be available.

One of the advantages of these radioactive sources is that they are comparatively easily and safely handled, and that they can be reactivated after decay by returning to the pile. They are standardized in the form of cylinders having a diameter equal to length with dimensions of 6 mm., 4 mm. and 2 mm. Specific activities can be as high as several curies per gram. The use of these isotopes is extending steadily in industry, both in Great Britain and abroad. The number which can be produced will be limited by the surplus neutrons available in B.E.P.O.

CLIMATIC LIMITS OF VEGETATION

THE climatic limits of the major types of vegetation and of plant species, especially those of economic importance, are a topic of great practical as well as theoretical interest. In Great Britain it has received comparatively little attention, doubtless because the range of climate in the British Isles is relatively insignificant and the effects of other ecological factors more striking. The subject was therefore appropriate for a joint meeting of Sections K (Botany) and K* (Forestry) of the British Association held at Birmingham on September 1.

Prof. P. W. Richards (University College, Bangor) opened with a discussion of the climatic limits of the Tropical Rain Forest. The optimum conditions for its development are found in areas such as the Malay Peninsula, where the climate is characterized by high and evenly distributed rainfall. Towards the periphery of the Tropical Rain Forest (using the term in the broad sense originally proposed by Schimper), the rainfall becomes more seasonal in its distribution, until a limit is reached where evergreen forest gives way to deciduous forest or savanna. This increasingly uneven distribution of rainfall is accompanied by an increase in the seasonal variation of temperature, but there is little reason for believing that temperature plays much part in determining the limits of the rain forest in lowland country. The altitudinal limit on mountains seems to be partly due to temperature, though even there other factors, such as reduced light intensity due to cloudiness, are probably important. In general, the evidence points to moisture conditions as playing the chief part in limiting the rain forest, which is thus controlled by factors affecting the ability of the vegetation to maintain its water balance rather than by factors affecting photosynthesis or the length of the growing season.

If this is so, we should not expect a very close correlation between the rain forest limits and any simple expression of climate, since factors such as soil texture, drainage, etc., affecting water uptake, are likely to be as important as factors affecting the rate and amount of water lost in transpiration.

The complexity of the factors controlling the boundary of the rain forest is well illustrated in Africa. In the Central Congo basin, Bernard[1] found a satisfactory correlation between the distribution of typical rain forest, peripheral transitional areas and savanna with Köppen's *Af*, *Am* and *Aw* climates respectively; but in West Africa conditions are not so simple. In Nigeria the boundaries between 'True Rain Forest' and 'Mixed Deciduous Forest' and between the latter and the savanna seem to be correlated not, as might be expected, with the length of the dry season, but with the total annual rainfall. As the annual total depends largely on the amount of rain falling in the wet months, which is far in

excess of what can be taken up by the vegetation or stored in the soil, it is likely that the controlling factor is really the evaporating power of the air during the dry season. Recent work has shown a fairly close relation between the vegetational boundaries and the lowest mean monthly relative humidity. The limits of the rain forest in Nigeria are, however, not determined solely by climate, but are also influenced by edaphic factors such as soil depth and texture.

The next contributor, Prof. A. A. Boughey (University College of the Gold Coast), taking the place of Prof. John Walton, who was unable to be present, showed a colour film of Nigeria. The three climatic zones of the West African savanna, Guinea, Sudanian and Sahelian, were depicted.

Prof. A. Austin Miller (Reading) said that a hundred years ago the prospect of finding a simple correlation between the distribution of vegetation and climate seemed good. This optimism had proved ill-founded, and ingenious efforts to replace simple climatic values by more complicated expressions had been unsuccessful because they tried to be universal in application, they ignored factors other than climate, and were attempts to fit the vegetation to the climate rather than *vice versa*. The factors controlling types of vegetation as diverse as Tundra, Steppe and Tropical Forest are probably quite different and must be independently determined.

One control which can be demonstrated to be important, though only at fairly high latitudes or altitudes, is 'accumulated temperature'. This value, also called the 'remainder index', is a device for assessing the accumulated effective warmth, measured in day-degrees, above some more or less arbitrary threshold value. The method of calculating day-degrees recommended by the Meteorological Office cannot be applied on a continental scale; but a good approximation is obtained if the difference between the monthly mean temperature and the threshold is multiplied by the number of days in the month.

The importance of accumulated temperature was recognized by Boussingault in 1837. At first the freezing point was used as the threshold temperature, but later it was found that a figure around 42° F. is more suitable, at least when temperate crop plants are being considered. The basal temperature is different both for different plants and for different plant functions. For citrus fruits, recent work in California suggests 55° F. as the correct threshold and 1,200 day-degrees as the minimum requirement for satisfactory fruiting.

With plant formations the choice of a threshold temperature bristles with difficulties. Nevertheless, there is close agreement between the Arctic timber line and a value of 18 month-degrees above 43° F. Experience is against the view that the efficiency value of each degree above the threshold is equal; but an empirical comparison of climate at the limits of vegetation types is likely to give better results than attempts to fit the increase in rate of growth with rise of temperature to an exponential curve. To illustrate this, data have been assembled for a large number of stations near the northern timber line in Eurasia and North America. In all these stations the mean temperature of the warmest month is higher than 50° F. (thus finally discrediting the 50° isotherm for the warmest month). A growing-season of two and a half months over 43° is enough for coniferous trees in continental climates; but in maritime regions a growing season up to four months is required. Sixteen–twenty month-degrees are needed away from maritime influences. There is no evidence to suggest that temperatures of, say, 50°–60°, are more effective than those of, say, 40°–50°. This gives some encouragement for the belief that, except where superseded by killing frosts, the critical factor limiting vegetation types in high latitudes is accumulated temperature, which can best be expressed as a remainder index. This should give a measure of the heat received, during a period yet to be defined, above a critical threshold.

The last speaker, Mr. J. MacDonald (Forestry Commission), considered a practical aspect of the problem, namely, the importance of climatic limitations in British forestry. In Britain, exotic trees are of prime importance because the native tree flora is so small. Climate restricts the number of species which can be grown and limits the range within which particular species are successful. It affects both the establishment and regeneration of trees and their over-all performance.

In Great Britain occasional severe winters and frosts during the growing season are more important than mean temperatures and variations in the seasonal distribution of rainfall. Eucalypts reach large dimensions in favoured localities in Scotland and could be used in forestry, but for exceptional winters; and Asiatic larches are excluded from practical use because of their susceptibility to late spring frosts.

Japanese larch and Corsican pine illustrate the effect of climate on the range of a species for forestry purposes. The former can grow almost anywhere in Britain, but it is much more successful in the north and west than in south-eastern England, probably because it requires fairly abundant rainfall during the growing season. The Corsican pine also grows in all districts, but is not reliable above 700 ft. This seems to be owing to frosts in autumn; Day has shown that the cambium is still active in October.

Frosts in the growing season are indeed the most hampering feature of the climate of Britain for the forester. This is especially true of Breckland, where frosts may occur even in June and July. A possible solution to this problem is to mix frost-resistant with less hardy species, so that the latter obtain some protection during the stage of growth when they are most susceptible. A more permanent solution may be to select late-flushing strains or to breed in frost-resistance by crossing. One example of the effect of climate on regeneration is the enormous loss of tree seedlings due to frost-lift, especially on impervious soils.

The most important way in which climate affects British forestry is by fixing an upper limit for successful planting. The chief factor involved is undoubtedly exposure to wind, though mechanical injury by snow is also important. Little is known about this subject, because in the past foresters rarely tried to plant trees at high elevations and the natural forests of Britain give little clue to the safe upper limits for planting. Trial plots at various altitudes near Beddgelert in North Wales suggest 1,250–1,750 ft. as the practical limit for forestry, but different species are strikingly different in their behaviour at high altitudes, and much more information is required.

In the open discussion which followed the papers, Dr. Syrach-Larsen (Denmark) pointed out that *Pinus radiata* is an example of a tree with a very small range as a native species, but capable of

growing as a crop under a very wide range of conditions. Other speakers stressed the importance of extreme, as well as mean, conditions, and also directed attention to the importance of microclimates.

P. W. RICHARDS

[1] Bernard, E., "Le climat écologique de la Cuvette Centrale Congolaise", *Pub. Inst. Nat. Agric. Congo Belge*, 1945.

'FRESHLY FRACTURED SURFACE' THEORY OF SILICOSIS

By B. M. WRIGHT

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FROM time to time, references have appeared in the literature of silicosis to the importance of fresh grinding of silica in the production of disease. Although this question appears never to have been experimentally investigated*, certain recent publications have suggested that the belief in the importance of freshness is widespread, and has influenced the conduct of experiments, as well as leading to the evolution of theories based on the assumption that it has been completely proved. It therefore seems worth while considering the history of this theory, and the evidence for and against it.

The idea appears to have been first mooted in 1935 when, following the publication of the work of Bragg[1] on the crystal structure of silica, it was suggested by Heffernan[2] that this substance's peculiar biological activity could be explained by the presence of unsatisfied valencies at the surface of its particles.

Heffernan recognized that these valencies could be satisfied by hydration, which would occur very rapidly in any normal atmosphere, and therefore it was necessary to postulate, in support of the theory, that only freshly fractured dust was active. There was no evidence in favour of this postulate, and even at that time there was considerable experimental evidence against it. The work of Gardner[3] had shown that it was possible to produce silicosis in animals by exposing them to the inhalation of clouds produced by stirring up commercial ground silica. Although Gardner was in the habit of buying this by the ton ready ground, and keeping it for many years before use, he never observed any deterioration in its power to produce silicosis. Moreover, one of his most strikingly successful experiments[4], which was extensively quoted by Heffernan (*loc. cit.*), was the parenteral injection of graded sizes of quartz, the grading being produced by a tedious process of water sedimentation and decantation, involving the suspension of the silica in water for periods of days before its injection, so that there would be ample time for hydration and leaching of the surface to take place.

The possibility that freshly fractured silica surfaces were especially active was again suggested in 1938 by Briscoe and others[5], as a result of experimental studies of the physico-chemical properties of finely ground materials. They suggested it as a possible ". . . explanation of the failure of attempts in the past to induce silicosis in animals by exposing them to artificially induced dust clouds". They did not state what experiments they referred to; but since there are a number of other possible explanations for the failure of attempts of this kind, a hypothesis which purports to explain the failure of any experiment must also explain the success of those of Gardner.

Although these defects in the 'freshly fractured' silica theory were well known to many workers in the field of experimental silicosis, no arguments were publicly adduced against the theory and, as a result, it became tacitly accepted as true by many people, and was adduced as an explanation of certain other phenomena. For example, Denny, Robson and Irwin[6], in their classical experiment on the prevention of silicosis with metallic aluminium, used a tumble-mill method for the production of the quartz cloud, and attributed the fact that they produced silicosis in rabbits in such a short period as six months to the use of a 'freshly fractured' cloud. In the absence, however, of any precise data about the concentration and size analysis of the cloud (they sampled only with a konimeter), it is unjustifiable to interpret their results in this way.

In 1947 Policard[7] reasserted the theory and gave the following examples:

(1) In spite of the fact that the sheep in the North African desert are continually exposed to the inhalation of sand, they do not develop silicosis. This he attributed to the fact that desert sand was weathered and therefore had no unsatisfied surface valencies.

(2) Sand-blasters are liable to silicosis because, although only exposed to the inhalation of sand which, as stated under (1) above, is weathered, and therefore harmless, the sand is broken up by heat and impaction and therefore presents 'freshly fractured' surfaces.

(3) Silicosis used to be common among millstone workers, in spite of the fact that the concentration of the dust cloud to which they were exposed was apparently very low, because the dust was freshly generated and therefore 'active'.

Policard's statements were not much disputed at the time, although King[8] suggested that the period required for hydration was so short that it would take place usually before the inhaled particles reached the alveoli, and also pointed out that, as mentioned above, Gardner had frequently produced silicosis in animals with dust nearly twenty years old.

The fallacy in the 'desert sand' theory was pointed out later by Heywood[9], who quoted the evidence of Bagnold[10] to show that desert sand contains very few particles less than about 200 μ in diameter and that the airborne dust in the desert comes from adjacent arable land and is almost entirely non-siliceous. The failure of desert sheep to develop silicosis can therefore be readily understood, and the liability of sand-blasters to the condition can be explained simply by their exposure to the finer particles produced by the shattering of the sand grains, without any need to postulate special activity of the surfaces of the particles.

The third example adduced by Policard is entirely speculative, since there is little or no evidence about the concentration and composition of the dust to which the workers were exposed.

These objections, however, appear not to have been generally recognized, and the 'freshly fractured' theory continues to enjoy a popularity for which it is difficult to see any justification. For example, Briscoe[11], Heffernan[12,13] and Policard[14] have all

* Recently, Rüttner (*Z. Unfallmed. Berufskr.*, 1, 66; 1950) has published results of experiments in which silica dust extracted from the lungs of deceased silicotics was injected intraperitoneally into mice and shown to be as active as freshly ground dust. These results cannot, however, be accepted without reserve, as the process of extraction of the dust from the lungs involved vigorous treatment with strong acid, which might be said to have created fresh surfaces on the particles.

recently reaffirmed the theory without bringing forward any new evidence in support of it, and finally Weyl[15] has suggested a new (though similar) theory, one of the main pillars of which is the assumption that silicosis can only be caused by freshly fractured dust.

In brief, Weyl has brought forward evidence that atomic oxygen is present at the surface of ground silica, and he suggests that this explains the peculiar effect of silica on animal tissues. Since the presence of atomic oxygen is a transient phenomenon, the assumption that freshly fractured silica is the only active form is essential to his theory. Another feature of the phenomenon is that it is much more striking in the case of clay than in the case of silica. Weyl fits this observation into his theory by assuming that clay can cause silicosis; in fact, however, clay not only does not cause silicosis, but may even[16] prevent it. It is therefore possible, without disputing the validity of his observations, to say that they are unlikely to have anything to do with silicosis.

Another phenomenon which Heffernan[17] and others have suggested can be explained on the 'freshly fractured' theory is the inhibition of the biological activity of silica by the presence of aluminium. However, it is equally possible to explain this phenomenon on the basis that the activity of a silica particle is concentrated at its surface, a theory which, as will be seen, is almost indisputable.

Although it is possible that freshly fractured dust is, in fact, biologically more active than 'old' dust, it would seem to be improbable; all the information available suggests that the fresh surfaces reach equilibrium with the surrounding atmosphere in a matter of seconds or minutes, and even if they reach the alveoli in an active condition, their activity will presumably be destroyed as soon as they are wetted by the alveolar fluids. Considering that the time required for the development of silicosis in man is a matter of years, and even in the smallest animal a matter of weeks, the importance of such a transient property is likely to be negligible. It therefore seems that, knowing what we do about the great differences of concentration and composition of the types of clouds that are produced by different industrial and experimental procedures, it is unnecessary to postulate such an unlikely mechanism to explain the differences in their toxicity.

Finally, it may be suggested that the question should at any rate be submitted to experimental study. Although this undoubtedly could be done, it would not be a simple experiment. For example, a possible technique would be to expose two comparable groups of animals, one to silica dust from a grinding mill directly and the other to the same dust after it had been collected, stored and redispersed. Apart, however, from the great difficulty of maintaining a constant concentration and size analysis in a grinding mill cloud, the exact imitation of such a cloud by redispersion would require the most refined technique. Moreover, in order to ensure that the two clouds were exactly similar in all respects, including the proportion of very fine particles, it might be necessary to study both by electron microscopy. It will be seen, therefore, that the cost and complexity of the experiment would probably be out of all proportion to either the practical importance or the theoretical interest of the question.

At present, the explanation of the action of silica which is most in favour is the so-called 'solubility' theory[18]. This has been repeatedly and probably justly criticized on physico-chemical grounds, in that the 'solubility' of silica is a meaningless concept. It is true that if silica dust is shaken in water or aqueous liquids for long periods, silica, in a non-particulate form, can be recovered from the liquid, but the amount which will go into 'solution' is a function of time and of the amount and surface of the dust present. Thus, the 'solubility' of silica is not like that of a substance like sodium chloride, the solubility of which (when in a saturated solution) is a function of temperature only, and is unaffected by the amount of solid present, provided that enough time is allowed for complete saturation.

Although the 'solubility' of a given sample of silica *in vitro* is correlated closely with its surface area, its correlation with its pathogenicity, although close, is not perfect, as has been shown by King[18]. However, any other theory which may be put forward about the nature of the surface activity of a silica particle, which purports to describe it or account for its biological effect, must take into consideration the fact that the activity is apparently permanent, and not immediately destroyed by exposure to tissue fluids. In short, it resembles a catalytic action, and while it is true that this does not explain it in any way, it brings it into line with a number of other well-established and thoroughly investigated phenomena in unrelated fields, with the possibility that any discoveries in these fields may prove to be applicable also to silica. Their application, however, will not be possible unless it is clearly understood what precisely are the biological properties of silica which are unique, and which require explanation.

These properties can be summarized as follows:

(1) Silicon dioxide (SiO_2), whether crystalline or amorphous[19,20], when injected into any tissue (not only the lungs) of a large variety of animals, in a suitable form, will produce a series of pathological changes, culminating in fibrosis, which are unlike those produced by any other mineral that has been investigated.

(2) In order to produce these effects, the particles of silica must be less than about 3 μ in average diameter[4] but more than about 100 A. The upper limit is well established but the exact position of the lower limit has not yet been fully investigated. It is known that even if the particles are of colloidal size, they are very toxic[20] but they produce an acute inflammatory reaction not readily distinguishable from that caused by many other substances.

(3) This property of silica is a function of its surface, as evidenced by the fact that: (*a*) it is only shown by particles less than a certain size; (*b*) within limits, the effect of a given weight of silica is proportional to the fineness of the particles of which it is composed; (*c*) it is apparently exerted without obvious loss of material; (*d*) it is inhibited by the presence of a substance such as aluminium or iron oxide which may be adsorbed on to the surface of the silica.

(4) Apart from its own effects, silica has the property of facilitating the proliferation of tubercle bacilli in animal tissue[20], a property which is not shown by other necrotizing substances.

(5) The biological activity of silica, although demonstrable in animals as low as fish[21], has not been demonstrated in tissue culture and is probably not present[22,23]. A considerable amount of further research is required; but it appears that the effect of silica is that of a tissue poison rather than a cell poison.

From what has been said, it is easy to point to a number of lines on which research is needed, either

to consolidate ground already partly covered, or to clarify questions at present still obscure.

(1) The whole range between about 3 μ and 100 A. has not been systematically explored, although it has been studied down to 0·5 μ[24]. At some point in this range particles become so small that they are for practical purposes colloidal. It would be of great interest to explore this range and study the transition from the particulate to the colloidal effect, since it seems that particles less than a certain size are harmless from the point of view of silicosis.

(2) The apparent synergy between silicosis and the tubercle bacillus may be associated with the fact that their effect on tissue is so similar that it has been suggested by Fallon[25] that it is, in fact, exerted through the same mechanism, that is, the disruption of phagocytes. A limited amount of work on the effect of silica on the tubercle bacilli *in vitro*[26] has led to somewhat inconclusive results but suggests that the stimulation of the growth of the tubercle bacillus occurs only in tissue.

(3) Only a limited number of tissues in a relatively small range of animals has been investigated by the simple technique of injection. The gap between the fish and the tissue culture is a big one, and although a large number of tissues, including lung, liver, spleen, muscle, peritoneum, testis, eye, and subcutaneous tissue have been studied, there are some notable omissions, for example, nervous tissue. It is to be hoped that work will be done to cover these deficiencies.

(4) Although it has been stated by Gardner[19] that amorphous silica is as active as crystalline, the evidence on which this statement is based is, though probably good, somewhat thin[21], and further work to confirm it is required. This work will be complicated by the fact that only certain forms of amorphous silica are active and the presence of relatively small amounts of impurities are sufficient to render it quite inert[21].

(5) It seems to be unlikely on the face of it that silica is unique. The search for substances with similar properties has been limited in the past by the fact that usually only substances of industrial importance have been considered. The suggestion of Evans[27] that other substances with similar crystal structure or physical properties should be investigated is a promising one, and should be further explored. Although Evans's own work on the importance of the piezo-electric property of quartz has not so far produced conclusive results (and is in any case ruled out of court if the evidence of Gardner on the activity of amorphous silica is to be accepted), it would obviously be valuable to explore the properties of a number of minerals in a systematic fashion, in order to compare them with silica.

Having now considered the laboratory investigation of the biological activity of silica, it remains to discuss shortly the assessment of its activity as an industrial hazard. Policard and others have attempted to attribute variation in the incidence of disease in different occupations to the freshness or otherwise of the dust to which the workers are exposed. Speculation of this kind is of limited value unless accompanied by precise quantitative data about the time and intensity of exposure, and the composition and size analysis of the airborne dust. All that has been said above about the activity of silica applies to its activity in the tissues, and information about the composition of the materials from which the dust is derived is of little use unless it is supplemented by studies of the actual dust breathed. Recently, Hatch[28] has reviewed the requirements of a system of dust sampling which will give an adequate description of the hazard, and has pointed out the absolute necessity of a complete study of the size distribution and composition of the airborne dust. It can therefore be said that no statements about the difference in dust exposure between one occupation and another, or one experiment and another, have any validity unless the dust cloud concerned is fully described.

In conclusion, it should be emphasized that there is room for more careful investigation along well-established lines in the study of silicosis and other pneumoconioses. No investigation of an industrial pneumoconiosis hazard is complete without a full description of the cloud as it actually exists in the breathing zone of the men, and, in the case of silicosis at least, it appears that this description should include some electron microscopic studies. Similarly, any animal inhalation experiments are likely to be difficult to interpret unless the cloud to which the animals are exposed is completely studied and controlled, and the difference between the characteristics of their respiratory system and that of man has been fully investigated.

It may be objected that the instruments and techniques for carrying out these investigations do not exist. The answer is that there is no theoretical reason why they should not exist, and that it would be better to spend some time in evolving them than to continue carrying out investigations and experiments in such an incomplete manner that no useful conclusions can be drawn from the results.

My thanks are due to my colleagues of the Pneumoconiosis Research Unit for their helpful criticism during the preparation of this paper, and to Dr. A. J. Vorwald and the staff of the Saranac Laboratory for allowing me access to the work of the late Dr. L. U. Gardner.

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ST. SALVATOR'S COLLEGE, ST. ANDREWS: QUINCENTENARY CELEBRATIONS

By Prof. JOHN READ, F.R.S.

IN 1911, St. Andrews, the oldest Scottish university, celebrated the quincentenary of its foundation in 1411 by Henry Wardlaw, Bishop of St. Andrews. This ancient seat of learning, so rich in history and tradition, has now paid a similar tribute of remembrance to its premier College of St. Salvator, founded and endowed as a residential college by Bishop James Kennedy in 1450. The proceedings opened on September 20 with a commemorative service in the collegiate church of St. Salvator, graced by the presence of Her Majesty the Queen and attended by members of the St. Andrews and Dundee Colleges and School of Medicine of the University, and by leading representatives of State, Church and Law in Scotland, together with academic delegates from many universities, colleges and other learned corporations. At the close of the service of thanksgiving the Queen unveiled a window and shrine in memory of members of the University who fell in the Second World War.

The sequence of events will live long in the memory of all those who were privileged to take part in them. Academic pageantry, gay heraldic shields and flags, bright autumn sunshine, sparkling sea, invigorating air, historic buildings: all helped in the creation of a cavalcade of picturesque scenes truly characteristic of Andrew Lang's "haunted town by the Northern Sea". From the age-old chapel of Bishop Kennedy the company walked in procession along North Street to St. Salvator's Hall, one of the University's most modern and handsome buildings. Here, a group of scarlet-gowned students, mounting a platform at the entrance to the beautiful dining-room, sang in unison the haunting air and words of the Latin grace of the College. The Queen, wearing the scarlet LL.D. gown and black velvet cap of St. Andrews, proposed in gracious terms the toast of the ancient foundation of St. Salvator. "This College," said Her Majesty, "has endured many trials during the past five centuries ... for these escapes we must be grateful, remembering that it is easier to destroy than to build up ... the university system of Scotland has undergone many changes in the past 150 years, but the individuality of St. Andrews as a collegiate university remains unaltered, and our societies of masters and scholars flourish beyond the dreams of their founders."

In reply, Sir James Irvine, principal of the United College of St. Salvator and St. Leonard, and principal and vice-chancellor of the University of St. Andrews, said that no honour could be more esteemed than that of the Queen's presence among them. The St. Andrews Colleges bore the same relationship to the University as did the family to the State. It was a remarkable thing that the collegiate system which developed naturally in England at the close of the Middle Ages should have been found adaptable to the changed conditions of the twentieth century. Even the great Universities of Harvard and Yale had adopted collegiate sub-division, which seemed to be the only safeguard against educational mass-production, and the only sure way to preserve the master–disciple relationship in higher learning.

In the afternoon the Duke of Hamilton, chancellor of the University, presided in the Younger Graduation Hall over a large audience, honoured again by the presence of the Queen. In a sparkling commemorative oration, the Earl of Crawford and Balcarres traced the origin and growth of the University and of the College of St. Salvator, and referred to some of the outstanding teachers and students, such as John Napier and James Gregory, whose names live in the records of the College. "In the brave company of St. Salvator's men of action," he said, "we watch young Montrose riding to his matriculation. We find in his rooms his Seneca and Xenophon, his cross-bow inlaid with mother-of-pearl, and his golf clubs. We see him hunting, playing tennis, competing for the silver arrow with his friends Dalkeith, Elcho, Sutherland, Lorne, and passing on to his strange destiny." Applause greeted his reference to "the famous carbohydrate research school of St. Andrews" and to "Sir James Colquhoun Irvine, F.R.S., thirty-fourth successor in direct descent of Master John Almare", who in presiding "over the destinies of our University adds lustre to a great inheritance and will hand to posterity a tradition which he has so much enriched".

Honorary degrees were conferred at this ceremony upon Dr. James Craigie, Mrs. Annie Cameron or Dunlop, Sir W. S. Duke-Elder, Prof. Louis Landré (University of Paris), Prof. J. D. Mackie (University of Glasgow), Mr. S. C. Roberts (Master of Pembroke College, Cambridge), Sir J. T. Sheppard (Provost of King's College, Cambridge), Mr. A. H. Smith (Warden of New College, Oxford), and the Rev. W. E. K. Rankine (Minister of St. Andrews).

On the following day, the first of the Dow Lectures, recently founded by Prof. D. R. Dow to encourage students to gain some knowledge of the rich historical background of the University of St. Andrews, was delivered to a large audience, including delegates and guests, in the Hall of the United College. In this lecture, entitled "The University of St. Andrews in Transition, 1895–1950", Sir James Irvine reviewed the critical period in the history of the University falling within his own experience as student, teacher and administrator. At the end of the lecture numerous visiting delegates presented congratulatory addresses, which were placed for safe keeping in an ancient charter box. The delegates represented academic or other learned foundations, mainly of a collegiate nature and often as old as, or even older than, St. Salvator's College. The Colleges of Oxford and Cambridge, as well as Scottish foundations, were richly represented, and other delegates came from Paris, Dublin, Harvard, Yale, Princeton, and from the Royal Society, the British Academy and other distinguished societies. The good feeling existing between Town and Gown in St. Andrews found cordial expression at the ensuing civic luncheon held in Hamilton Hall, to which members of the University and delegates had been invited as guests of the Provost, magistrates and councillors of the Royal Burgh of St. Andrews.

The celebrations were marked further by the striking of a special medal and the issue of two new St. Andrews University Publications: "The Life and Times of James Kennedy, Bishop of St. Andrews", by Dr. Annie I. Dunlop, and "Veterum Laudes", edited by Dr. J. B. Salmond. Of the twelve chapters of the latter book, three are devoted to the philosophers, the men of science, and the medical men who have been associated with St. Salvator's College.

On each evening of the celebrations, for the first time in the history of St. Andrews, certain of its picturesque buildings were floodlit: these included St. Salvator's Chapel, the United College, the romantic ruins of the Castle and Cathedral, Holy Trinity Church and the West Port. Altogether, the fame that St. Andrews has won as an unsurpassed setting for charming and dignified academic ceremonials has never been better justified than on this memorable occasion in the long history of the University.

OBITUARIES

Field Marshal the Right Hon. J. C. Smuts, O.M., C.H., F.R.S.

In the course of a long and exceptionally active life, Smuts acquired an outstanding reputation as lawyer, soldier, statesman, writer and philosopher. It would have been surprising if a man so versatile had been lacking in appreciation of those advances in the knowledge and practical application of science which have been perhaps the most distinctive feature of the age in which he lived: nor, indeed, was he. He had, I think, no technical training in scientific matters; but I can testify that he followed developments closely and was keenly alive to the social and economic implications of recent scientific discoveries and to their bearing on international relations.

I had many talks with him during the War about the significance of the work on nuclear energy to which so much time and money were being devoted, and I had the opportunity in that connexion of introducing him to Prof. Niels Bohr, whose distinguished record was already familiar to him and of whom he had become an ardent admirer. Thereafter they had many discussions together in my presence. Smuts was thrilled by the possible economic significance of the discovery of vast quantities of low-grade uranium ore in the gold-bearing formations of the Rand. In quite another connexion I found that he had been following with the liveliest interest the recent spectacular discoveries demonstrating the South African origin of the earliest known forms of prehistoric man.

It is, however, in the argument by which Smuts developed the philosophical conception to which he applied the term 'holism' that one finds the clearest evidence of his extensive knowledge and understanding of the course of recent scientific researches. In successive chapters he sets out in non-technical language the basic theories of atomic structure, relativity, the doctrine of the space-time continuum, quantum theory, cell structure, Mendelism and much else. All this collated information serves to sustain his first main contention that the chief gaps in human knowledge are those which separate the phenomena of matter, life and mind, and leads up to, without establishing, his suggestion that in the grand design of the universe there must be an essential unity. From this, two broad conclusions emerge. The mysteries of life and mind may perhaps, when the key has been discovered, be unravelled in the same way as the mysteries of matter; and, while humanity may pass through a "series of vast secular crises", and may be passing through such a period now, all will eventually develop according to the master plan of the Creator. Incidentally, in the absence of knowledge of that master plan, mere human planning will be largely vain, as Smuts more than hinted in his inaugural speech as Chancellor of the University of Cambridge. His faith was ardent, and such was its basis.

In all discussions, military, political or philosophical, the serenity of the man's mind was remarkable. It is, indeed, a tragedy that at this juncture the world should be deprived of his wise, kindly and courageous counsel.

JOHN ANDERSON

Prof. H. Gordon Jackson

Birkbeck College, the University of London and zoological circles have suffered a sad loss by the recent death in a road accident of Harold Gordon Jackson, master of the College and professor emeritus of zoology in the University. Born in Sussex in 1888, he passed his early days in Liverpool, attending Merchant Taylors' School and the University of Liverpool. When qualified, he was appointed research assistant to Sir William Herdman, and spent much time at the Marine Laboratory, Port Erin, and at sea on Herdman's yacht, so acquiring a fondness for marine biology and Crustacea which characterized his later zoological work. In 1913 he was appointed to a lectureship at the University of Birmingham; but the tenure of this was interrupted by service with the Royal Warwickshire Regiment during the First World War.

A long association with the University of London was begun in 1921, when Jackson was appointed reader and head of the Zoology Department at Birkbeck College, newly admitted by the Senate as a school of the University. From that date he played an outstanding part in the development of the Department of Zoology and of the College itself, so that in 1941, when an acting master was required, he was the obvious choice; on Sir John Maud's resignation in 1943, he was persuaded—much against his will, for it meant a cessation of zoological work—to accept the mastership. Started reluctantly, as it was, and at a time when war dangers made the very physical existence of the College a continuous hazard, his period of mastership was an immense personal success. The University pressed the excellent administrator that he proved to be into service in many capacities, so that at the time of his death Prof. Jackson was deputy vice-chancellor, chairman of the Academic Council and a governor of four of its schools. Other bodies, too, gladly took advantage of his skill, and he was, at one time or another, on the Council of the Association of British Zoologists, the Council for the Promotion of Field Studies, the Freshwater Biological Association and the Marine Biological Association.

Prof. Jackson's scientific work was almost entirely concerned with Crustacea, in later years predominantly with the systematics of land isopods, on which he published many important papers. But zoology was only one of many things in which he was deeply interested: music, architecture and literature all occupied his attention, and he could talk as understandingly to his Faculty of Arts as to his Faculty of Science. The main appeal of these (another link with

Herdman) was antiquarian—it was classical music, old castles and churches that aroused his keenest interest, and one would often find him reading some eighteenth-century writer in the 'tube train' on his way to College. Prof. Jackson's main success was, however, personal, and it is in this that his old students and colleagues will remember him—the kindly interest he took in their schemes, great or small; the touches of humour and the deft similes with which he enlivened his lectures; the breadth of his sympathies for, and the wise and tolerant attitude to, the endless succession of activities that make up the daily life of a thriving university college.

A. GRAHAM

WE regret to announce the following deaths:

Sir William Benham, K.B.E., F.R.S., emeritus professor of biology in the University of Otago, on August 21, aged ninety.

Prof. Costantino Gorini, *correspondant* for the Section of Rural Economy of the Paris Academy of Sciences and formerly professor of agricultural bacteriology in the Istituto Superiore Agrario, Milan, on September 3, aged eighty-five.

Prof. E. A. Milne, M.B.E., F.R.S., Rouse Ball professor of mathematics in the University of Oxford, on September 21, aged fifty-four.

Mr. C. T. White, Government botanist in Queensland.

NEWS and VIEWS

Use of the Term 'Vitamin P'

AT the meeting of the Federation of American Societies for Experimental Biology in Atlantic City, April 17–21, 1950, the following recommendation of the Joint Committee on Biochemical Nomenclature of the American Society of Biological Chemists and the American Institute of Nutrition was adopted: "The term 'vitamin P' was first applied to a substance present in lemon juice. It was said to be effective in reducing the extent of hæmorrhages and extending the duration of life in scorbutic guinea pigs and was also proposed for the treatment of vascular purpura. Subsequent studies have failed to substantiate these claims, and the identity of a substance of a vitamin nature has not been established. Continued application of the term 'vitamin P' to one or another of a group of polyphenolic substances will lead only to confusion. It is therefore recommended that the term 'vitamin P' should no longer be employed."

Study of Statelessness

THE United Nations Department of Social Affairs has issued "A Study of Statelessness" (pp. xiii+190. Lake Success, N.Y.: United Nations; London: H.M. Stationery Office, 1949. 1.25 dollars; 9*s*.), which presents a general survey of national legislation and international agreements relating to stateless persons, and indicates the main systems in force. The survey, which was made at the request of the Economic and Social Council, considers both the improvement of the status of stateless persons and the elimination of statelessness. The former, however, only offers a temporary solution, and the real goal is the elimination of statelessness. As a preliminary measure, the study recommends that States be invited to refrain from taking discriminatory measures against stateless persons in territories under their jurisdiction and to deal with them in accordance with the Conventions of 1933 and 1938. It is also recommended that, in consultation with the International Refugee Organisation and other specialized agencies concerned, a fresh convention be drafted which would include provisions concerning such subjects as personal status, property rights, the exercise of trades and professions, education, a travel document taking the place of a passport, the procurement of documents enabling stateless persons to perform various acts of civil and administrative life, entry, sojourn and expulsion. To eliminate the source of statelessness the study further recommends that every child should receive a nationality at birth and that no person throughout his life should lose his or her nationality until he or she has acquired a new one. Certain principles are also suggested for reducing the number of existing cases of statelessness.

British Institute of Management

IN his chairman's address at the annual general meeting of the British Institute of Management on July 26, Sir Charles Renold said that in little more than two years remarkable progress had been made in getting the Institute established as a national organisation. Its conferences, which are meeting a definite need, have been a major factor to this end. Besides the absorption of the British Management Council and the Confederation of Management Associations and the projected merger with the Institute of Industrial Administration, a further measure of co-ordination is being achieved by the contacts facilitated by the accommodation of various bodies with the Institute at Management House. The goodwill of *Industry* and *British Management Review* has been purchased by Management Publications, Ltd., and, under the new title *The Manager*, the former is being developed as the organ of British management. The Information Service of the Institute is constantly developing, and a series of specialist handbooks is in preparation. A handbook giving full details of the national scheme for intermediate certificates in management studies, which the Institute is conducting in conjunction with the Ministry of Education and the Scottish Education Department, is to be issued, and a subcommittee has been studying the whole question of foremanship training in technical colleges.

Sir Charles referred in some detail to the considerations which have led the Council of the Institute to conclude that the time is now ripe for the Institute to set about the development of professional qualifications in general management as the basis for building a professional membership. The Council recognizes that such professional qualifications are desirable only in so far as they can establish themselves with industry as significant indications of capacity to undertake general management responsibility, and that an indispensable element in granting such qualifications is an assessment of personal qualities. It is intended to make it clear from the outset that the Institute is building for the future, and that its primary concern is with the young manager. Arrangements will nevertheless be made for senior managers, whose practical achievements merit recognition, to be associated with the Institute, for example, in a separate 'transitional' category of professional

membership. Referring to the need, already emphasized in the Council's report, for a much greater degree of financial support from industry and commerce if the Institute is to become self-supporting within a reasonable period, Sir Charles said that a new campaign for corporate subscribers is to be started in the autumn.

Mining and Metallurgy Abstracts

THE science and art of metalliferous mining are practised in every part of the globe, and, because no two deposits are exactly alike, the annual output of scientific and practical papers in many countries and different languages is so great that no mining engineer, wishing to keep up to date in current practice, can possibly do so. When to this are added the important ancillary professions such as extraction metallurgy, mineral concentration or 'dressing', applied geology, mechanical and electrical engineering applied to mining, the river of information flowing from the mines is in a perpetual spate. The survey of world literature on mining (excluding coal) and allied subjects (classified according to the Universal Decimal Classification), which is published monthly by the Institution of Mining and Metallurgy, Salisbury House, Finsbury Circus, London, E.C.2, meets a need long felt by members of the allied professions which it serves. The first series, published in the July 1950 issue of the *Bulletin* of the Institution, contains nearly two hundred abstracts, the average length of each one being of the order of a hundred words. When it is remembered that mining is frequently practised in districts far from a library, the value of these abstracts to the manager of a lonely mine becomes apparent. Not only are they useful to the individual in isolated mines; but they also fill a want long felt by busy engineers in more crowded areas because they will save both time and money spent searching the literature. Particular attention is paid to the application of pure science to mining problems, for example, surface chemistry in flotation processes.

Bibliography of Seismology

Two further numbers of the "Bibliography of Seismology", published by the Dominion Observatory, Ottawa, continue the very valuable work of keeping seismologists and others interested up to date with world publications on pure and applied seismology and allied subjects (Publications of the Dominion Observatory, Ottawa. **14**: Bibliography of Seismology, No. 4: Items 6858–7003, July to December 1948. By W. G. Milne. Pp. 71–96. No. 5: Items 7004–7131, January to June 1949. By W. G. Milne. Pp. 97–133. (Ottawa: King's Printer, 1949–1950.) 25 cents each). The evaluation of the seismicity of various regions of the earth and the elucidation of earth structure by means of earthquake waves still form a large proportion of research in pure seismology. The study of microseisms continues its world-wide appeal as instanced by W. M. Jones's paper on New Zealand microseisms (item 7058), Marion H. Gilmore's paper on the relation of microseisms to meteorology (item 7035) and others. The accurate delineation of salt domes is also still an incentive to the seismic prospector (item 7032). Seismological items from the columns of *Nature* are listed in the bibliography, and Hirosi Kawasumi contributes twenty-four pages of references to papers written in Japan during 1939–47. Some of these have been published; but others, which have been received at the publication offices of various research institutions and societies in Japan, are intended for publication when the opportunity occurs.

Electrical Power-System Network Analyser

AT the Nelson Research Laboratories of the English Electric Co., Stafford, there was placed in operation at the beginning of the year an alternating-current network analyser. The design and extension of electrical power supply networks nowadays often involve the consideration of a number of alternative schemes, each of considerable complexity and requiring for its analysis a large amount of numerical computation. The amount of computation required for the assessment of a group of such alternatives would be prohibitive. The A.C. network analyser or calculating board is, in effect, a very flexible model which can be arranged to represent the generators, loads and inter-connexions of a power system. The calculating board is so arranged that the appropriate circuit elements can be associated quickly and conveniently to form the required network, and the values of voltage, current and power at various points in the system measured. For the operation of this analyser, a frequency of 500 c./s. has been chosen in order to reduce the size of the iron-cored reactors. Twelve generator units, controllable in magnitude and phase, are available, and impedance units cover the range of impedances normally encountered in power systems. In the metering system negative feed-back amplifiers are employed to operate the instruments, so that the connexion of an instrument disturbs the network to only a negligible extent. The normal applications of the analyser will be to studies of load sharing, fault currents and system stability. This installation is an important addition to the resources of the electrical engineering industry in Britain for dealing with power system problems.

Marine Radar in the Port at Baltimore

IT is reported in the February issue of the *Journal of the Franklin Institute* (**249**, 173; 1950) that a harbour radar system has recently been installed at the Recreation Pier in the port at Baltimore. This is the third major port in the world to be so equipped, the other two being Long Beach, California, and Liverpool. The radar equipment, which comprises a Westinghouse commercial marine radar unit, provides port operators with a 12½-in. radar chart of harbour shipping movements at ranges from 80 yards to 40 miles. It will be used in a navigational aid research programme designed to assist ships entering and leaving the port of Baltimore in fog and bad weather, to provide continuous observation of harbour shipping, and to give immediate information of the location of shipping casualties in the harbour.

British Scientific Instrument Research Association

THE British Scientific Instrument Research Association has recently published an attractive illustrated booklet describing the activities and various departments of the Association. The Association has the honour of being the oldest of the some fifty existing industrial research organisations operating under the ægis of the Department of Scientific and Industrial Research. It was founded in 1918 and is now an integral part of the scientific instrument industry with more than a hundred firms in membership with it. Full-page photographs of the individual

laboratories at 'Sira' show clearly the excellent facilities available. The chairman of the Association is Sir Ronald Weeks, and Mr. A. J. Philpot is the director of research and secretary.

Courtaulds' Scientific and Educational Trust Fund: Awards

COURTAULDS' Scientific and Educational Trust Fund was formed in 1948 for the promotion of study and research in branches of science with a bearing on textiles, plastics and allied industries. The Fund provides scholarships and also laboratory apparatus and equipment for educational and research institutions. The awards for 1950 have been recently announced as follows.

Research scholarships, of value £375, in a branch of science related to the textile, plastics and other allied industries, and tenable at the places indicated, have been awarded to: D. C. Blackley, C. T. Greenwood and E. J. Hybart (Department of Chemistry, University of Birmingham), T. C. N. Carroll (Christ Church, University of Oxford), A. G. Davies (Edward Davies Chemical Laboratories, University College of Wales, Aberystwyth), Miss J. B. Hayter (Chemistry Department, University of Edinburgh), K. Leedham (Selwyn College, University of Cambridge); and one scholarship of £150 to M. Coleman (Department of Chemical Engineering, Imperial College of Science and Technology, London). Research scholarships in textile technology, of value £300, have been awarded to: M. Chaikin and R. Cockburn (Department of Textile Industries, University of Leeds), J. F. Clark and L. B. Hallows (Department of Textile Chemistry, College of Technology, Manchester); and one scholarship of £125 (for one year only) to K. W. Geddes (Department of Colour Chemistry and Dyeing, University of Leeds).

Animal Health Trust: Fellowships and Scholarships

THE Animal Health Trust has announced the following awards of research fellowships and research training scholarships: Wellcome veterinary fellowship to P. S. Pugh, for the study, at the Department of Animal Pathology, Cambridge, on metabolism of the ruminant with the view of investigating clinical disorders; Imperial Chemical Industries fellowship to B. A. Cross, for research, at the School of Physiology, Cambridge, on neuro-hormonal mechanisms in lactation, with particular reference to the activation of the posterior pituitary by the suckling stimulus; Cooper fellowship to K. M. Dyce, to enable him to study parasitology, and, particularly, helminthology, at the London School of Hygiene and at the Trust's Equine Research Station, Newmarket; research training scholarships to T. A. Douglas, L. W. Hall, J. G. Phillips, A. J. Stevens and W. J. Brinley Morgan. The Animal Health Trust, founded in 1942 as the Veterinary Educational Trust, is a body supported entirely by voluntary subscriptions. Since its foundation it has awarded fellowships and scholarships, totalling more than £52,000, for the extension of veterinary educational facilities in Great Britain.

The Night Sky in October

NEW moon occurs on October 11d. 13h. 33m., U.T., and full moon on October 25d. 20h. 46m. The following conjunctions with the moon take place: October 10d. 02h., Saturn 2° N.; October 10d. 13h., Mercury 3° N.; October 15d. 09h., Mars 4° N.; October 20d. 15h., Jupiter 2° N. In addition to these conjunctions with the moon, Mercury is in conjunction with Saturn on October 6d. 08h., Mercury 0·3° S. Mercury is a morning star, rising at 4h. 20m. and 5h. 15m. on October 1 and 15 respectively; but, as the planet is in superior conjunction on November 1, it is badly placed for observation towards the end of the month. Venus is a morning star, rising about an hour before the sun on October 1 and forty-five minutes before the sun on October 15, but later in the month is too close to the sun to be favourably observed. Nearly all the illuminated disk is visible and its stellar magnitude is −3·4. Mars, an evening star, sets at 19h. 25m., 19h. and 18h. 45m. on October 1, 15 and 31 respectively. About October 6 the planet is very close to Antares, after which it moves east of the star. Jupiter, in the constellation of Aquarius, is visible in the earlier portion of the night, setting at 2h. 15m., 1h. 15m. and 0h. 10m. at the beginning, middle and end of the month respectively. Saturn, close to β Virginis during the first week of the month, is a morning star, rising at 4h. 45m. and 3h. 10m. on October 1 and 31 respectively. A large number of occultations, mostly in the constellation of Taurus, occurs during October, especially on October 28, and the following list is limited to stars brighter than magnitude 6: October 4d. 0h. 19·9m., 49 Auri. (*R*); October 21d. 23h. 32·4m., *h* Aquar. *m* (*D*); October 28d. 02h. 58·8m., 17 Taur. (*D*); October 28d. 04h. 02·4m., 20 Taur. (*D*); October 28d. 04h. 05·8m., 23 Taur. (*D*); October 28d. 04h. 07·9m., 16 Taur. (*R*); October 28d. 04h. 18·2m., 17 Taur. (*R*); October 28d. 04h. 36·1m., η Taur. (*D*); October 28d. 04h. 40·3m., 20 Taur. (*R*); October 28d. 04h. 41·7m., 23 Taur. (*R*); October 28d. 05h. 40m., η Taur. (*R*); October 28d. 19h. 57·6m., χ Taur. (*R*); October 31d. 23h. 51m., 47 Gemi. (*R*). *D* and *R* refer to disappearance and reappearance respectively, and the latitude of Greenwich is assumed.

Announcements

LORD RUSSELL and Lord Dunsany will be the chief speakers at a dinner which the Philosophical Society of England will hold on October 4 at the Waldorf Hotel, in honour of Lord Russell, who is patron of the Society. This Society, which was founded in 1913, was reconstituted in 1948, and has since had its headquarters at 11 Chandos Street, Cavendish Square, London, W.1.

Two series of lectures on special aspects of dairy technology have been arranged by the Department of Chemistry, Chelsea Polytechnic, Manresa Road, London, S.W.3. They are designed for persons holding executive posts in dairy or allied industries and those of professional standing in food chemistry, public health, etc. Both series consist of four lectures, which will be given on Tuesdays at 7.15 p.m., starting on November 14 and February 13, respectively, and the cost of each series is 7*s*. 6*d*.

THE United Nations Educational, Scientific and Cultural Organisation is compiling a list of requests from libraries all over the world for out-of-print war-time issues of journals and other publications. It is hoped to fulfil these appeals by obtaining surplus copies from libraries and private collections, and, so far as Great Britain is concerned, the British National Book Centre will be used as the collecting centre. Those who have surplus copies to spare should get into touch with the British National Book Centre at the National Central Library, Malet Place, London, W.C.1.

INFLUENCE OF TEMPERATURE ON THE MICELLARY SIZE OF SALT AEROSOLS

By Prof. L. DAUTREBANDE
Stanford Research Institute, Stanford, California

AEROSOLS of a micellary size less than 1 micron, and made of salts in water or other volatile media, evaporate within a fraction of a second at room temperature and relative humidity less than 80 per cent[1], thus leaving behind in the atmosphere the remaining crystals or solid remnants of the solute. Unless the outlet of the aerosol generator is directly connected with an atmosphere of high relative humidity, these solid particles constitute the aerosol. The evaporation of small spheres, such as are produced, is accurately proportional to the radius of the sphere and not to its surface[2-4]. This process of evaporation can be accelerated by warming up the aerosol immediately after its production[5,6], thus reducing the size of the micelles to a considerable extent. The reverse is also true. If an aerosol containing dry particles of sodium chloride, for example, is cooled, the solid particles recapture water from the saturated air and form large coalescent droplets. By this simple method, one can not only obtain large particles from an aerosol initially composed of very small micelles, but also produce large aggregates, in fact much larger in size than are generally observed at room temperature and normal relative humidity, with the same material and the same aerosol generator.

An aerosol was produced by a Generator No. 15, described elsewhere[7], then passed through a glass tube 200 cm. in length by 5·5 cm. inner diameter for 5–30 min. At different points in the tube the temperature of the aerosol was varied by heating the tube locally (100–160° C.) with an electric resistance or by cooling it with 'dry ice' (0 to −30° C.). Slides bearing collodion screens were placed at the bottom of the tube at points where the temperature was normal, where it was low, and immediately after the heating point and/or after the cooling point (where the temperature was normal again). Immediately after the aerosol dispersion was completed, the tube

Fig. 1. Influence of temperature on the micellary size of aerosols. Aerosol from a 1 per cent sodium chloride solution dispersed by a hand-bulb-operated generator (No. 15) through a tube 200 cm. × 5·5 cm. for 5 min. and collected during 2-hr. sedimentation on collodion screens placed at the bottom of the tube at points of different temperatures. Left, at 32° C. Right, at −5° C. Electron microscope. Gold-shadowed. Note the formation of large aggregates in the cooled aerosol

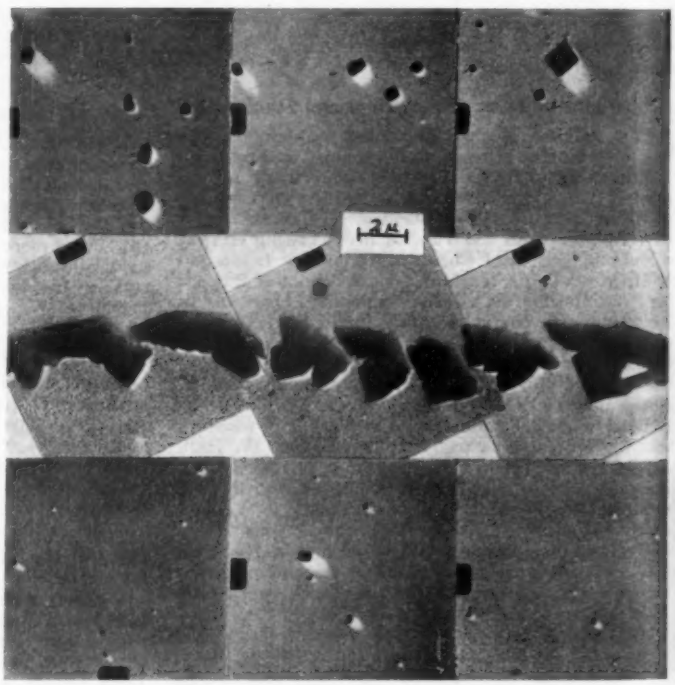

Fig. 2. Influence of temperature on the micellary size of aerosols. Aerosol from a 1 per cent sodium chloride solution dispersed under 10 lb./sq. in. through a tube 200 cm. × 5·5 cm. for 30 min. and collected during 30-min. sedimentation on collodion screens placed at the bottom of the tube at points of different temperatures. Top, at 22° C. before region of cooling. Centre, at −29° C. Bottom, at 22° C. after the aerosol had passed through a region heated to 160° C. Electron microscope. Gold-shadowed

was sealed at both extremities and the aerosol allowed to settle down for 30 min., 1, 2, 3 and 15 hr. Fig. 1 shows the appearance of an aerosol from a 1 per cent sodium chloride solution collected at 32° C. and at −5° C. respectively. It can be seen that the cooling of the aerosol (*a*) increases the particle size, (*b*) increases the extent of aggregation, and (*c*) increases the amount of material collected, as a result either of a more rapid sedimentation or of the thermal precipitation gradient.

Fig. 2 shows the appearance of an aerosol collected at 22° C., at −29° C., and after warming up. It can be seen that particles which have escaped the cooling-off precipitation (at −29° C.) are smaller after heating (lower row) than before heating (upper row).

Fig. 3 shows the appearance of an aerosol collected at 22° C., at 0° C., and again at 22° C. after the cooling-off region. The photograph shows that the aerosol which has not been collected in the cold region (at 0° C.) is composed of a mixture of large and small particles.

It is believed that this simple procedure of cooling the aerosol can be applied (*a*) in therapeutics for the treatment of the upper respiratory passages (where large particles are deposited preferentially) simultaneously with the treatment of the lower respiratory tract (where small particles readily penetrate); (*b*) to atmospheres containing fine dust particles, with or without the addition of aggregating aerosols[8–11]; similarly, to industrial recovery of waste, toxic or valuable products (stacks, cyclones, chimneys, scrubbers, etc.); and (*c*) to local conditioning of animal or plant textile fibres[12], etc. These variations in the micellary size of aerosols may also play a part in the production of some phenomena related to the pollution of the atmosphere (visibility[13,14], eye, nose and throat irritation[15], etc.).

These experiments have been made with the assistance of Messrs. R. Capps and J. Shaver. The electron microscope photographs were taken by Mr. C. Glassbrook. [Feb. 10.

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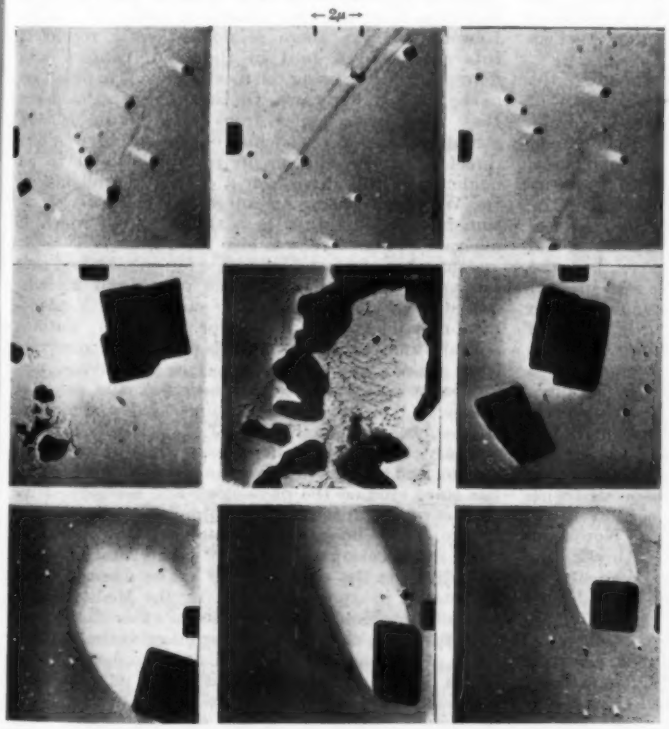

Fig. 3. Influence of temperature on the micellary size of aerosols. Aerosol from a 1 per cent sodium chloride solution dispersed under 10 lb./sq. in. through a tube 200 cm. × 5·5 cm. for 15 min. and collected during 30-min. sedimentation on collodion screens placed at the bottom of the tube at points of different temperatures. Top, at 22° C. Centre, at 0° C. Bottom, at 22° C. after the aerosol had passed through the cooling region. Electron microscope. Gold-shadowed

FUNGUS DISEASES OF ANIMALS

ALTHOUGH fungi are less important than bacteria as pathogens of man and animals (the converse of the relationship of these organisms to disease in plants), the first parasitic disease to be recognized was the 'muscardine' disease of silkworms caused by the fungus *Beauveria bassiana*. This discovery by the Italian worker Bassi in 1835 opened a new era in the understanding of disease and helped to pave the way for the development of bacteriology later in the century. The indisputable significance of bacteria to medicine and veterinary science led to the almost total eclipse of medical and veterinary mycology, and only during the past few decades has it been realized that fungi pathogenic for man merit careful and intensive study even if they are responsible for few major diseases. During the nineteenth century a number of mycotic infections of man and animals were described, for the most part by medical men with no special training in mycology. Professional mycologists, on the other hand, who moved so freely in and out of the field of plant pathology, rarely ventured into medical territories, to the detriment of both medicine and mycology. Since the First

World War, however, and particularly in the United States, fungi of medical importance have been studied by trained mycologists working in close contact with medical men and the results have at times been spectacular. More recently, in Great Britain, too, there has been a revival in interest in medical mycology; but here, as elsewhere, veterinary mycology has been neglected, and the first veterinary mycologist in Great Britain and the Commonwealth has yet to be appointed. Symptomatic of the growing interest in fungus diseases of animals was the meeting of the British Mycological Society held at the University of Reading on July 26, when veterinarians, medical men and mycologists devoted a day to the discussion of problems of common interest.

The meeting opened with an account by Mr. J. D. Blaxland (Ministry of Agriculture's Veterinary Laboratory, Weybridge) of moniliasis in turkeys. This disease, first recognized in the United States in 1932 [1], was unrecorded for Great Britain until 1949, when five outbreaks, involving the death of more than eight thousand of a total of twelve thousand turkey poults, were investigated by Blaxland and Fincham[2]. The affected poults did not usually show any diagnostic symptoms. Young birds dying from acute disease were of normal body weight; but older birds infected for a longer period showed uneven growth and a general unthriftiness. On post-mortem examination, however, crop lesions were usually found either as a flocculent greyish-white exudate adherent to the underlying mucous membrane or, in chronic cases, as a thickening of the crop wall, the inner surface of which was covered by a mass of yellowish-white necrotic material giving a 'turkish towelling' effect.

From these crop lesions isolations were made of the yeast-like fungus *Candida albicans*, the subject of a paper by Miss P. M. Stockdale (University College, Exeter), in which she described the methods commonly employed for the determination of the morphological and physiological characters used for the differentiation of this and other species of *Candida*. The circumstantial evidence all pointed to the responsibility of *C. albicans* for the death of the birds and for the infectious nature of the disease; but the factors underlying these epidemic outbreaks are not clearly understood. Infection experiments, still in progress, on turkey poults and chicks with strains of the fungus strongly pathogenic for rabbits have not resulted in epidemics, and in some instances after a period of sub-normal development the young birds appear to have recovered, although *C. albicans* has been isolated from representative individuals killed for cultural and histological examination. It was noticed in the naturally occurring outbreaks that some birds showed symptoms usually associated with nutritional deficiencies and also, in certain cases, nervous symptoms recalling those of Newcastle disease. In only one of four of the outbreaks for which data were available was there evidence of unsuitable diet, but in two the hygienic conditions were poor.

Additional evidence for the complex etiology of moniliasis in poultry has been obtained from a survey of the incidence of crop lesions and of *C. albicans* in turkeys and turkey poults, chickens and chicks, and in ducklings, geese and goslings which have come up for routine post-mortem examination at the Veterinary Laboratory since the beginning of this year. Most of these birds had died from other causes, but from 9 per cent of 127 turkey poults and 43 per cent of 73 adult chickens *C. albicans* has been isolated from birds which in some cases exhibited crop lesions and in others did not. It would thus appear that *C. albicans* is not uncommonly associated with normal birds, and in poultry, as in man, the origin of the moniliasis is endogenous; and that similar difficulties are likely to be experienced in evaluating the significance of yeasts found associated with pathological conditions.

Dr. R. E. Rewell, until recently pathologist to the Zoological Society of London, dealt with aspergillosis of birds and other animals, a disease which in contrast to moniliasis has an exogenous origin. Aspergillosis, caused by *Aspergillus fumigatus* and less frequently by other species of *Aspergillus*, takes an annual toll of birds in the London Zoo and also of poultry throughout Britain. It is characteristically a disease of the respiratory system. The air sacs are the region most frequently affected, and it is only occasionally that the abdominal viscera are also involved. Usually, lesions in the abdominal viscera are tuberculous, and in a survey carried out at the London Zoo during 1946–48 [3] no evidence was obtained to support earlier claims that infection by *A. fumigatus* and the tubercle bacillus may occur in the same organ. The time of incidence of aspergillosis shows an interesting contrast to tuberculosis. The former is primarily a disease of the early days of captivity, while the latter attacks birds long captive. During the recent survey, of 76 birds dying from aspergillosis, 62 had been less than six months in the Gardens, while 36 of 42 birds dying from tuberculosis had been more than six months in captivity. In Dr. Rewell's opinion there is no authentic record of tuberculosis in a bird in the wild, contact with domestic poultry being the most plausible explanation of the few recorded cases. On the other hand, evidence that wild birds suffer from aspergillosis is very strong, though not conclusive. Attention was also directed to aspergillosis in a buffalo[4] and to an epidemic of this disease in a colony of wallabies at the Whipsnade Zoo. An interesting case of a condition resembling thrush in a shoebill from which *C. albicans* was isolated was also recorded.

A number of fungi pathogenic for animals and man are yeast-like in the parasitic phase and mycelial under the usual conditions of culture. This phenomenon may be an adaptation for parasitism; but it is perhaps more probable that it is a potential 'dimorphism' which enables such species to invade new habitats. *Histoplasma farciminosum*, the cause of epizootic lymphangitis in equines and a dimorphic species, was discussed by Dr. J. J. Bullen, who, after gaining experience of the disease while on service in Assam and Burma during the Second World War, has since studied the physiology and serology of the fungus at the Institute for Animal Pathology, Cambridge, where he succeeded in elucidating the conditions for effecting the mycelial-yeast transformation by adjusting the environment[5]. The disease, which is endemic in countries bordering the Mediterranean but absent from Britain, shows other interesting features. The characteristic symptom is the development of abscesses in the superficial lymphatic vessels which in the course of about three months spontaneously heal but not before fresh abscesses have developed farther along the affected vessel. The course of the disease is protracted and control of outbreaks, by isolation and slaughter, very difficult. Weeks or even several months after the apparent elimination of the disease from a group of horses or

mules a new case may appear. The epidemiology is obscure; but it is highly probable that the parasitic activity of *H. farciminosum* is confined to equines and thus it differs from the allied fungus *H. capsulatum*, the cause of histoplasmosis in man, dogs and certain rodents, which was one of the examples mentioned by Dr. J. T. Duncan in a comprehensive review of the relation of mycoses of animals to disease in man.

Histoplasmosis is one of the group of mycotic diseases including coccidioidomycosis (*Coccidioides immitis*) and sporotrichosis (*Sporotrichum schencki*), in which man and animals are subject to the same external hazard of infection by fungi able to live saprophytically. In such diseases the animal hosts are often of considerable importance in epidemiological studies on the disease in man by indicating the geographical areas in which the parasite is endemic and also, as in coccidioidomycosis, by helping to propagate the parasite. In contrast to this is another group of mycoses in which man contracts infection directly from a diseased animal. Sometimes the reverse occurs, as when the school cat becomes infected from a child with ringworm, which is a typical disease of this type. Cats, dogs and cattle are very generally infected by dermatophytes, and in most country districts almost all human ringworm is caused by fungi derived from animals, in contrast to the predominance of specifically human ringworm fungi in large towns. No serious efforts are made to control dermatophytes on domestic and farm animals, so a large reservoir is available from which farm workers can contract infection, sometimes sufficiently severe to involve a period in hospital, and through the agency of which the education of children can be disturbed.

Actinomycetes, perhaps more properly classified as bacteria but often referred to the mycologist for identification, also came under discussion. Dr. Rewell noted a disease of wallabies attributed to an aerobic member of the group, while attention was directed to the anaerobic forms which cause actinomycosis in man and cattle by Mr. D. Oxford, who has recently begun a study of the status of the human and bovine pathogens. Mrs. Oxford would be grateful for material of these diseases, which should be sent to her at the Department of Bacteriology, Foresterhill, Aberdeen. G. C. AINSWORTH

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INTRA-CELLULAR DISTRIBUTION OF VITAMIN C IN THE ADRENAL CORTEX

By DR. GEOFFREY H. BOURNE
Department of Histology, London Hospital Medical College

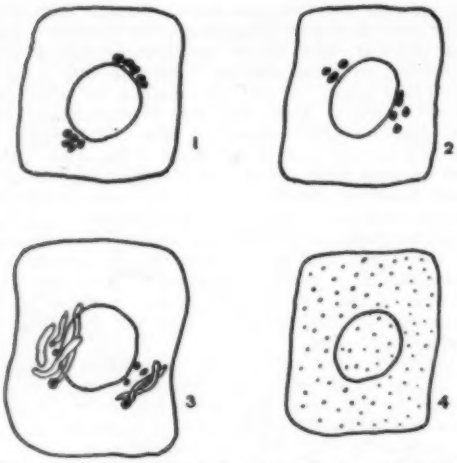
ATTENTION has been directed to the localization of reduced silver granules in the Golgi region of adrenal cortex cells after treatment with the vitamin C reagent, acetic acid – silver nitrate[1,2]. Afterwards, Barnett and Fisher[3], basing their observations on chemical models, claimed that the localization of the granules in the Golgi region was no indication that the vitamin was localized there. Certain fallacies in their argument were pointed out by Bourne[4]. Sosa[5] has claimed that silver granules produced after treatment with the vitamin C reagent only occur in the Golgi region if the preparation is afterwards 'fixed' in hypo. Dean and Morse[6] have stated that the granules only appear in the Golgi region of adrenal cortical cells if the gland is fixed more than five minutes after death. Hoch Ligeti and Bourne[7] have, however, shown that there is a cycle of distribution of vitamin C granules in the adrenal cortex. One stage is represented by the aggregation of the granules in the Golgi region, another by the presence of numerous fine granules aggregated near the inner surface of the cell membrane and a third by the discharge of the granules from the cell into the cortical sinusoids.

Claims for and against the localization of vitamin C in the Golgi region are dependent upon what is meant by the Golgi apparatus, and recent work by Palade and Claude[8] suggest that it might be desirable to reconsider our views on this problem.

Palade and Claude claimed that common Golgi fixatives cause the production of myelin forms from numbers of phospholipoid vacuoles already existing in the cell, and that it is these artefacts which are normally described as the Golgi apparatus. The authors claim that the myelin forms are produced by either the primary acidic reaction of the fixative, or by a secondary acidity produced by the reaction of the fixatives on the tissue. In view of the high acidity (10 per cent acetic acid) of the vitamin C reagent, it was considered desirable to study the penetration of this reagent into tissue disks, as used by Palade and Claude, prepared by crushing small pieces of tissue between slide and cover glass and permitting the reagent to penetrate at the periphery.

Pieces of adrenal cortex of the rat were prepared in this way, and the penetration of the silver nitrate–acetic acid reagent studied under oil immersion.

There is, first of all, a clear fringe, which appears to be the acid, advancing towards the centre of the disk from the periphery in which the protoplasm of the cells becomes precipitated. The silver ions appear to penetrate more slowly, and their penetration can be seen first of all as a yellow zone, followed by a wine-red zone, both of which move forward in order from the periphery towards the centre of the disk. The colour of these zones appears to be due to the reduction of the silver by vitamin C liberated from damaged cells and localized between the intact cells. As the yellow zone advances from the periphery, black granules can be seen forming in the cytoplasm of the cortical cells, and they become much darker when that region is overtaken by the wine-red zone. The granules in the cells in the outer part of the disk, which represented the outer zona fasciculata and zona glomerulosa, are localized in a juxta-nuclear (Golgi) region of the cell. Many of the inner cells of the disk, representing the inner fasciculata and the reticularis, showed numerous small granules scattered through the cytoplasm and not localized near the nucleus. This tendency for the outer cells of the adrenal, particularly those of the zona glomerulosa, to show localization of silver granules in the Golgi region, and of many of the inner cells to show the granules more widely distributed in the cytoplasm, is characteristic of the picture one frequently obtains from vitamin C preparations of the adrenal made in the normal way. The way these granules appear is



Figs. 1 and 2. Showing disposition of vitamin C granules in zona glomerulosa cells 30 sec. after contact with acetic acid – silver nitrate solution. Note that granules appear to have run together in one part of Fig. 1

Fig. 3. Cell of outer zona fasciculata twenty minutes after treatment with acetic acid – silver nitrate solution. Note myelin bodies and some black granules in association with them. Note other black granules separate from myelin bodies

Fig. 4. Cell of inner part of zona fasciculata 30 sec. after contact with acetic acid – silver nitrate. Note fine black granules scattered through the cytoplasm

of interest because it has been suggested that the vitamin C is not localized in any cell organelle, but that it is diffused throughout the cytoplasm. The apparent localization of these granules in the formed elements of the cell, it has been suggested, may be due to the aggregation of the silver particles in these regions following their production in the cytoplasm by the vitamin present there. If this were the case, one would expect the granules to come slowly into view, but in fact they come very suddenly into view; one moment they are not there and the next they are visible. This is not what one would expect if they developed in these sites only as a result of diffusion of silver micelles from the rest of the cytoplasm.

It is of interest that M. R. Lewis has shown[9] that if mice are fed Nile-blue sulphate, fine blue granules may be seen scattered through the body of many of the cells of the cortex. She found the distribution of these granules to correspond exactly with the distribution of silver granules in the adrenal cortical cells as demonstrated in rat adrenals by Dean and Morse[6] and in chick embryos by Barnett and Bourne[10]. Since the lipoid vesicles, from which Palade and Claude[8] claim myelin figures develop, have the ability to concentrate dyestuffs, these results suggest that, even when the vitamin C granules are widely distributed in the cell, they are still incorporated in what represents—although they are not localized near the nucleus—the Golgi system, or complex, of the cell.

After the disk preparations of the adrenal cortex had been under the influence of the vitamin C reagent for ten to fifteen minutes, myelin forms began to develop in the cells; but they did not blacken with the reagent, thus indicating that they contained no vitamin C.

After three minutes penetration, there was no sign of the yellow zone, and the first indication of the advancing silver ions was the sudden development of granules in one cell after another. In the inner parts of the disk Liesegang rings became obvious; their frequency was less than the diameter of a cell, so that individual cells had one or two bands across them in which the granules appeared more concentrated. It is of interest that Liesegang rings have never been observed in adrenals impregnated in the usual way by the vitamin C reagent.

These experiments support the observations of Palade and Claude[8] that treatment of cells with acids may cause the development of myelin forms. They also suggest that the Golgi nets described in the adrenal cortical cells are artefacts, and that the true Golgi element of the cortical cell may be represented by a series of vacuoles, probably phospholipoid in nature, which have the ability to segregate various substances, including dyestuffs. They confirm my previous contention that vitamin C is not diffused through the cytoplasm but is localized in the Golgi vesicles of the cell. They also show that although vitamin C is found in the Golgi vesicles it is not necessarily present in the myelin forms which have been described as the Golgi apparatus in the past.

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OPERATIONAL RESEARCH

APPLICATION TO PEACE-TIME INDUSTRY

SCIENCE in Great Britain is often accused of lagging far behind that in the United States in its application to industry. It is encouraging, therefore, to see the development in industry of the war-time technique of operational research. Such research is an attempt to apply scientific methods to determine the effectiveness of operations. The application was clear enough in many war-time problems where there were complex organisations, new apparatus and often inexperienced executives. It has the same role in industry—to discover and marshal the facts as an adjunct to the executive's experience and judgment and so help him to make rational decisions.

Many of the successes of operational research come from the study and improvement of traditional methods; it is, therefore, sometimes looked upon as a short-term policy to get quick results. Were it no more it would be valuable; but that it can do and is doing more is shown by the lectures and discussions held under the auspices of the Manchester Joint Research Council during the winter of 1949–50, now published as a booklet*.

An introduction by Prof. P. M. S. Blackett, reprinted from the *Operational Research Quarterly*, poses two questions: Is it scientific? Is it new? The first he answers "yes by definition"; the second is not so easily answered categorically. Prof. Blackett finds newness not so much in the material to which the scientific method is applied as in the level at which the work is done, in the comparative freedom

* Operational Research: its Application to Peace-time Industry. Pp. 152. (Manchester: Manchester Joint Research Council, 1950.) 10s. 6d.

of the investigators to seek out their own problems and in the direct relation of the work to the possibilities of executive action. One of the lecturers, Mr. A. W. Swan, puts rather a different view. In defining operational research as scientific management plus the statistical approach, he infers that the statistical approach is what makes this a new subject. The truth perhaps lies in a combination of these two ideas: on one hand the development of new scientific methods applicable to the problem (particularly the statistical approach); and, on the other, the development of a new scientist-executive relationship which makes possible the application of the new methods.

In the series of five lectures, examples are drawn from a wide field. Mr. H. Bradley shows how analysis of foot dimensions has pointed the way to a more rational range of shoe sizes. Mr. D. Hicks outlines the task of operational research in the coal industry, and Mr. L. H. C. Tippett shows what has been done by the Cotton Industry Research Association. An example of a study of the operations of a steel rolling mill is given by Mr. A. W. Swan, and Dr. W. H. Glanville explains some of the problems undertaken by the Road Research Laboratory of the Department of Scientific and Industrial Research.

These examples admirably illustrate the type of problem which the operational research scientist may be expected to answer. They do not perhaps always so clearly demonstrate the relationship between scientific worker and executive which is necessary to achieve successful results. Sir Raymond Streat finds this failure particularly obvious in the case of the two research associations and concludes that research associations, although doing much excellent operational research in the general field, lack the close contact with the executive which would be necessary for them effectively to carry out projects of this type in individual firms. It might be added that research associations are primarily concerned with their industry as a whole and mostly lack resources to commit to specific projects of interest only to individual firms. This leads on to a discussion of the important problem of the application of operational research in firms which are too small to have their own organisation for the purpose. It is clear that there is a strong case for some outside body to supply specialist operational research workers for particular investigations in such firms; and the tentative conclusion is reached that the most likely source of these is from paid consultants.

The special position of the operational research investigator in the works calls for outstanding qualities of personality. He must work for, and report to, the high executive; yet he must also win the confidence of the shop managers and workers if he is to be able to pursue his investigations freely and gain access to the essential facts. There is danger, however, of over-emphasizing the importance of this aspect and of forgetting the essentially scientific nature of the work. Operational research is more than just common sense. In the discussions at Manchester there appears such a tendency to stress the importance of 'the right personality' almost to the exclusion of anything else, scientific ability being held at a discount. Scientific ability and personality are not incompatible, and both are required in operational research.

In discussions of the technical knowledge required, it seems to be the general opinion that an operational research worker does not need a detailed knowledge of the industry in which he is to pursue his investigations. Indeed, it is argued that only a minimum of such knowledge is to be preferred, since much of the value of operational research lies in ceaseless probing of existing practices, and it is difficult to question practices which one has been brought up to accept. There is, however, much in the alternative view that the operational research worker will be lost without considerable background knowledge. The solution may lie in team-work; the team could be led by an outsider, who could introduce the new ideas and take away on his departure any opprobrium which might arise through unpopular recommendations, while some, at least, of the rest of the team could be normally employed in the factory or shop.

A final verdict is not yet possible on operational research. This booklet sets out to clarify thought on the subject; in this, it could perhaps have been improved by judicious editing to avoid the verbatim reporting of minor exchanges which are sometimes tedious in print. Nevertheless, it contains important ideas and opinions and well merits study by those interested either academically or industrially.

R. T. Eddison

ADVISORY COUNCIL ON SCIENTIFIC POLICY

THIRD REPORT

While the most important feature of the third report of the Advisory Council on Scientific Policy is the support it affords for the establishment of one or more higher technological institutions, with suitable governing bodies of their own but fitted into the university system, the report also contains ample evidence that the Advisory Council is discharging its other standing responsibility of reviewing the appropriate organisation for scientific research in government establishments in Britain. On the question of scientific man-power, the Advisory Council remains a little hesitant. It is plainly dissatisfied with the accuracy and comprehensiveness of the results obtained from the Ministry of Labour's Survey of Scientific Manpower, at least as a basis for concrete recommendations; but the Council should be seeking rather than hoping for other means of providing this type of information. Data collected by the Ministry of Labour lead to the general inference that we are approaching a point where the short-term demand for trained scientific workers may be satisfied, but where temporary maladjustments may occur; continuing shortages of chemists and chemical engineers and a probable surplus of biologists are specifically mentioned, while special stress is laid on the serious shortage of science teachers in schools and the probability that the present level of salaries will have unfavourable effects on the quality of men of science recruited for the teaching profession.

Here, as in the question of the supply of technologists, the Advisory Council does not accept the existing demand as the sole criterion. It believes rightly that if the value of qualified men of science in executive positions is properly appreciated the demand for them will show a marked increase, and, similarly, that the existing demand for technologists should not be taken as a measure of the numbers needed if British industry is to maintain and improve its position in the world. While the Advisory Council may well hold that it is premature to reach any firm conclusion as to the extent to which facilities for higher technolo-

gical education should be supplemented, the qualification to its recommendation for the establishment of one or more colleges of applied science must not provide an excuse for indefinite postponement of this new experiment. Even if the new institutes of higher technology are established immediately, they cannot be expected to make an important contribution to higher technological education within much less than a decade. With the new demands on material and human resources, it is inconceivable that they will ever be established unless such resources are allotted to them as part of a considered distribution in which due, but not exclusive, regard is had to the competing demands of universities and industry and government departments.

On the government organisation for scientific research, besides the observations on the Department of Scientific and Industrial Research already considered (see *Nature*, September 9, p. 410), the Advisory Council states that a report received last November has fully confirmed the hopes entertained that the appointment of a chief scientist in the Ministry of Fuel and Power could make a valuable contribution to the discharge of the Minister's scientific responsibilities. The record of the first year of work of the new Division amply justifies the view that the Advisory Council took in its first annual report of the importance of creating a scientific division in executive departments with scientific responsibilities, and shows how much vitality is infused into research when its organisation and direction are planned in relation to the needs of potential users. The Advisory Council has also considered the organisation and needs of the Colonial Research Service, and particularly the comparative isolation in which members of this Service would inevitably work and the consequent difficulty which might be experienced in recruiting the best scientific workers for the posts. The Advisory Council feels strongly that the success of any scheme of research in the Colonies will depend upon the extent to which co-operation with the centres of research at home is made effective and the secondment is facilitated of members of the staffs of the research councils and the universities for periods of service in the Colonies.

In regard to co-operation between centres of research at home and overseas, it has been agreed with scientific representatives of the Colonial Office that before a research institution in the United Kingdom is asked to undertake work on behalf of the Colonies, the research council responsible for the institution would, wherever possible, be consulted. Provided overlapping and wasted effort is thus avoided, the Advisory Council sees great advantages in a continuing and increasing use by the Colonies of the facilities for agricultural research available in the United Kingdom. The organisation of ecological research was also considered, and the proposed programme of work of the Nature Conservancy has been discussed with its chairman, director-general and other members. The Advisory Council hopes that the establishment of the Nature Conservancy will encourage public recognition of the importance of ecology and create openings for trained ecologists. The responsibilities of the Conservancy are limited to Great Britain; but similar problems arise on a vast scale in other parts of the Commonwealth, and it is urgent to direct attention to the value of ecological work in the universities and elsewhere.

During the year the Council was consulted by the director of the Scottish Seaweed Research Association regarding a proposed attempt to introduce into British waters the type of foreign seaweed known as *Macrocystis*, in view of the comparative ease and economy with which it can be harvested compared with existing methods of harvesting the native *Laminaria*. A special committee, under the chairmanship of Sir Edward Salisbury, which was appointed by the Council, advised against the experiment on the grounds of risks to navigation and inshore fishing, and these conclusions were endorsed by the Council. The Council was also asked to examine existing departmental arrangements for controlling the use of potentially toxic substances or processes in the preparation of consumer goods, and appointed a special committee, with Prof. S. Zuckerman as chairman, for this purpose. Various problems relating to scientific work overseas, including the Technical Aid Programme, were also handled by the Advisory Council.

PHYSICS AT LIVERPOOL

THE Physical Society's summer provincial meeting was held at Liverpool on July 7 and 8 under the chairmanship of Prof. R. E. Peierls. The meeting gave speakers from the Experimental and Theoretical Physics Departments of the University an opportunity of presenting to members of the Physical Society and other visitors a picture of the work being carried on there in two main fields: nuclear physics, experimental and theoretical, on one hand; and the theory of the motion of electrons in solids, on the other. Contributions to the discussion from members of the audience provided many valuable comments and suggestions, and in some instances made known investigations on similar or allied lines being pursued elsewhere.

The meeting commenced with papers on the theory of solids. Recent developments arising from the work which Prof. H. Fröhlich and his collaborators, associated with the British Electrical and Allied Industries Research Association, have been pursuing over a number of years, on the interaction of moving electrons with the lattice vibrations in a solid, were surveyed by Prof. Fröhlich himself and Dr. H. Pelzer. The latter dealt mainly with conduction electrons in dielectrics, using a classical model for illustration. The excitation of lattice vibrations by the field of an electron moving in a known path can be calculated, the polarization being found at every point. Dr. Pelzer showed how the resulting rate of loss of energy by the electron can be evaluated as the total polarization energy produced in a layer of the medium lying far behind the electron and normal to its path, and of thickness numerically equal to the speed of the electron. A formula has been obtained[1] which is similar to one derived differently by A. Bohr. Also, the self-energy of the electron due to the interaction can be calculated, by integrating the interaction-energy density in the field over all space. This energy can be used to define an effective interaction mass, to be added to the ordinary mass of the electron. The interaction mass is proportional to the inverse cube of the velocity, and so diverges at zero velocity. However, a quantal theory would be expected to remove this divergence, owing to the diffuseness of the wave representing the electron. Dr. Pelzer referred briefly to a completely quantal

treatment of the problem by Fröhlich, Pelzer and Zienau[2]. This permits recalculation of the quantities previously obtained classically. The total effective mass of the electron turns out at low velocity to be very little greater than the ordinary mass. This was put forward as an argument against the Landau concept of self-trapping of an electron. Finally, Dr. Pelzer pointed out that in ionic and non-polar crystals, notably semiconductors, free electrons acting as intermediary agents could lead to absorption of electromagnetic radiation by the longitudinal lattice vibrations, although this is normally forbidden.

Prof. H. Fröhlich explained how the application to metals of such considerations of the interaction between electrons and the lattice vibrations has led him to a theory of superconductivity. He claimed that the problem of finding a mechanism which can separate two distinct states, the normal and the superconducting, by an energy of the known extremely small magnitude, is thus solved. However, the electromagnetic properties of the superconducting state have not yet been fully investigated. The calculations adopt the simple Fermi gas model for the unperturbed motion of the electrons, while the lattice vibrations are handled by methods familiar in quantum field theory. Interaction results in the excitation of virtual vibration quanta by the electrons. This can be considered as producing self-energy of the electron gas, which is calculated by the second-order perturbation method. Part of the self-energy is expressible as an interaction energy between pairs of elements of the cloud of electrons in momentum space. At absolute zero the distribution in this space should ideally be chosen to minimize the energy: some distortion of the Fermi sphere would in general be expected. Prof. Fröhlich has considered a family of distributions obtained by displacing outwards a thin shell of electrons from the Fermi surface. A minimum of total energy is obtained for a small displacement if a number F measuring the strength of the electron-lattice interaction is sufficiently large; but otherwise zero displacement gives the lowest energy. Superconductivity of the metal is identified with the condition of distorted ground-state, and its existence thus depends on F. This quantity can be estimated from the high-temperature conductivity. It is found to be of the required order of magnitude, and also its value for different metals seems to be roughly correlated in the correct way with the existence or otherwise of superconductivity. The properties of different isotopes of the same metal are simply related on this theory. Thus the superconductive transition temperature is inversely proportional to the square root of the isotopic weight. Recent experiments on mercury[3,4] have confirmed this dependence. In the discussion, Prof. R. E. Peierls expressed the opinion that the isotopic effect is strong evidence in favour of the theory; and he and others emphasized the desirability of carrying out experiments with more isotopes.

A paper by Dr. K. Huang dealt with the theory of F-centres, which are of particular interest as the simplest example of impurity centres. They have been carefully investigated experimentally by Pohl and his collaborators, but the theoretical discussion of many aspects has hitherto been only qualitative and tentative. Dr. Huang has set out to analyse more thoroughly two properties of F-centres, namely, (1) the shape of their absorption bands, which show broadening with rise of temperature, and (2) the photoconductivity, which falls off very rapidly when the temperature drops below a certain point. Accepting the general ideas which have been put forward to account for these phenomena by way of the interaction of the F-centre electron with the lattice vibrations, Dr. Huang presented a quantitative development of the theory. He has calculated transition probabilities using wave functions for electron plus lattice, analogous to those of Born and Oppenheimer for molecules, and treating the lattice approximately as a dielectric continuum. Absorption spectra at different temperatures, which he has plotted with the assistance of Miss A. Rhys, were shown to fit measured curves closely. The treatment of photoconductivity was not described in detail, but evidence was presented of a broad agreement with experiment.

Dr. B. Szigeti discussed the dielectric and elastic properties of ionic crystals. He proposed a model which would be consistent with the observed dielectric constant and would also conform to the Cauchy relations between the elastic constants, and to a newly derived relation between the compressibility and absorption frequency. Both the relations mentioned are experimentally well fulfilled for alkali halides. The essential feature of the model proposed is to take into account the distortion of the electron cloud of the ions due to the short-range repulsive forces. In an elastic deformation conditions are such that, even when this distortion is admitted, the restoring forces are effectively central, so that the Cauchy relations hold. As indicated above, the model also leads to a satisfactory relation between the compressibility and the absorption frequency. In an electric field, the distortions caused by the repulsive forces explain qualitatively the deviation of the experimental value of the dielectric constant from the value obtained if the polarization is attributed to the Lorentz force only. The model, in contrast to previous ones, gives the correct sign for this deviation of the dielectric constant.

The meeting passed on to topics in experimental nuclear physics. Mr. D. G. E. Martin gave a brief summary of the technique of the magnetic spectrometer for the measurement of the energy and intensity of β- and γ-radiation. He pointed out the importance of careful design of the apertures inside the instrument, so as to ensure that the minimum area of the internal surfaces of the spectrometer box is exposed to the view of both the source and the detector. Where the β-particles enter the detector they usually have to penetrate a thin foil, and absorption and scattering in this foil can lead to serious distortion of the spectrum in the region of small energies. Thin foils of 'Zapon' have been used, supported on copper mesh; but this arrangement is not satisfactory at the larger energies because the β-particles begin to penetrate the copper. When two counters are used in a coincidence arrangement in order to reduce the background counting-rate due to γ-radiation, the loss in the counting-rate due to the window is much greater for a particular energy of the β-radiation, because a β-particle scattered through a small angle in the window may not reach the second counter. Distortion of the spectrum may be produced also by scattering from the foil carrying the source itself, or by self-absorption in the material of the source. For measurements at an energy of 5 keV., the total thickness of foil and source should be less than 5 μgm./cm.^{2}. Various methods were described for the preparation of such sources. Mr. Martin went on to discuss the different types of detector which can be

used with a magnetic spectrometer, including the scintillation counter and the photographic emulsion. He then outlined the problems involved in the measurement of the intensity of γ-radiation and of internal conversion coefficients. The discussion was illustrated by reference to work done in the laboratory on the radiations from a thorium-active deposit[5,6].

Mr. B. Collinge gave an account of his work on the dead time of self-quenching counters. The limitations to the performance of self-quenching counters were briefly discussed, and the work of Simpson[7] and Hodson[8] on reducing the dead time of argon-alcohol counters was described. Their method is to attempt to collect the positive ions formed during the discharge on the central wire after each count. To do this, a circuit is used which switches the wire potential to a negative value with respect to the cathode for a few micro-seconds after each count. It was pointed out that there may be a different explanation of the reduction in dead times so obtained. Experimental evidence was given to show that a sudden reduction of the wire potential causes the ion sheath to be confined to the part of the counter wire close to the place where the particle has passed. The remainder of the wire, not being involved in the discharge, is sensitive to further ionizing events as soon as the wire potential is restored to the working value. By using a very short counter, so that localization of the discharge does not occur, it has been shown that a reduction in the dead time can also be achieved by ion collection in the way suggested by Simpson and Hodson. Results showing the effect of causing localization of the ion sheath on the dead time of a counter were presented. The dead time of a counter 30 cm. long was found to be 20 μsec. and independent of the counting-rate up to $1{\cdot}8 \times 10^4$ counts per minute.

Some recent work with the 37-in. cyclotron by Holt and Young and also by Hughes was described. This was concerned with the determination of the angular distribution of the disintegration particles from targets bombarded with deuterons of energy up to 8 MeV. In one investigation[9] a differential ionization chamber was used to detect protons from the reaction $^{27}Al(d,p)^{28}Al$. The protons from a target of aluminium foil emerged from the target chamber through a curved window of 'Cellophane'. Thus the angle between the detector and the beam of deuterons could be varied continuously from 25° to 145°. At each setting of the angle of the detector the spectrum of the protons was determined by the use of calibrated absorbers. The intensity of the protons belonging to a particular group was measured by finding the area beneath the peak in the spectrum belonging to that group. Results were shown for seven groups of protons and for bombarding energies of 4·6, 5·8 and 7·5 MeV. These indicate a general tendency for the intensity of the protons to increase towards the forward direction. In the case of the proton group of longest range, a number of maxima and minima occur in the curve showing the angular distribution. An extension of these experiments in which intensities could be measured at small angles indicates a large peak in the forward direction in the case of the group of longest range with a deuteron energy of 7·5 MeV. The intensity decreases by a factor of 30 between 0° and 25° in this particular case.

The angular distributions of the neutrons emitted from light elements bombarded with 8-MeV. deuterons have also been measured. A thick polythene layer proton recoil chamber was used to detect the neutrons. On account of the increase in sensitivity with increasing neutron energy, this method of detection gives more weight to the higher-energy neutron groups. In all cases the neutron distribution showed a pronounced forward maximum in intensity. The half-widths of the forward peaks were of the order of 30–40°, tending to decrease as the atomic number of the element increased. The forward neutron intensity also decreased as the atomic number increased, but not monotonically. In the cases of beryllium, lithium, magnesium and aluminium, there was evidence of a peak at a small angle to the forward direction, with actually a shallow minimum in the forward direction; this tendency became pronounced as the threshold on the detector was increased so as to limit detection to the highest energies. The forward neutron intensity was found to decrease by a factor of three, and the half-width to increase slightly for beryllium, magnesium and aluminium when the deuteron energy was lowered to 7·2 MeV. In the case of magnesium the distribution was isotropic at about 5·5 MeV. bombarding energy. Taken together, these results seem to provide strong evidence for a 'stripping' reaction, the deuteron being split up by the nuclear collision. This process would be expected to lead to a strong forward peak of either protons or neutrons, whereas the type of process involving an intermediate nuclear state would lead to a more or less isotropic distribution.

In the field of nuclear theory, Dr. R. Huby spoke on certain nuclear reactions which are supposed to proceed by a direct transition from initial to final state, without the intermediate formation of a compound nucleus, as in the Bohr theory. Direct processes were expected often to be distinguished by a forward maximum in the angular distribution of the emitted particles. As an example, he discussed calculations by A. B. Bhatia and K. Huang to account for the above-mentioned (d,p) and (d,n) observations by Holt and Young, and Hughes. By handling a modified 'stripping' process with the Born approximation, an angular distribution is obtained having roughly the correct forward maximum. In the discussion, Prof. Peierls referred to calculations made on the same problem at Birmingham, which lead to apparently similar results by a rather different technique. Another direct process mentioned by Dr. Huby was the inelastic scattering of charged particles by nuclei, owing to the electrostatic interaction. He and Mr. H. C. Newns obtain a formula which predicts cross-sections up to about 10^{-26} cm.^{2} for excitation of a single level, and which is in approximate agreement with certain experiments.

Two speakers dealt with the nuclear explosions occurring when a fast particle passes through, or a meson is absorbed by, a nucleus. Dr. K. J. Le Couteur spoke on his work relating particularly to heavy nuclei, for which the Bohr statistical model is assumed to be applicable, and Miss S. N. Ruddlesden on her and Mr. A. C. Clark's study of meson absorption by light nuclei, taking account of the initial configuration of the constituent nucleons in the nucleus. Dr. Le Couteur considered the relatively slow charged nuclear particles ejected in explosions. These are supposed to be evaporated from the excited nucleus, in a process which can be dealt with thermodynamically. Their statistical distribution can be calculated for given excitation energy of the nucleus. Simple approximate expressions have been obtained for (i) the mean energy of the charged particles as function of the excitation energy, (ii) the relation

between their mean number and mean energy, (iii) the relation between the standard deviation of the number and that of the energy. The fluctuations in the number are sufficiently small for this alone to give a good indication of the excitation energy. The calculations of negative meson capture by light nuclei, reported on by Miss Ruddlesden, lead to the relative probabilities of different modes of disintegration of the nucleus, and also to the energy spectrum of the charged particles ejected. Two types of meson-nuclear interaction have been considered. The lightest nuclei producing charged particles, namely, helium-3 and -4, were dealt with first, and later carbon and other α-particle nuclei. The energy spectrum of α-particles issuing from carbon can be made to agree quite well with experimental results from Bristol[10], by adjustment of one available parameter.

The final afternoon of the meeting was occupied with an inspection of the new Nuclear Physics Laboratory and the George Holt Physics Laboratory, after an introductory talk by Prof. H. W. B. Skinner on the layout and purpose of the former. He stated that the new Laboratory has been designed to accommodate two particle accelerators, a large synchro-cyclotron and a Cockcroft–Walton generator. Started in the middle of 1948, the main part of the building was completed by the end of 1949. It is hoped that the large cyclotron will be running by the end of 1951. The one-million-volt high-tension set which is now nearly complete follows conventional design. Two new features are incorporated: the ion source is of the radio-frequency type suggested by Thonemann, and the magnet used to deflect the beam through 90° is of the permanent type. This has a motor-driven shunt which enables the magnetic field to be varied between zero and a maximum of 10,000 gauss. The synchro-cyclotron is designed to accelerate protons to an energy of 400 MeV. The electromagnet has poles 156 in. in diameter and contains 1,640 tons of steel, which have already been delivered. The two energizing coils are wound from 1½-in. square-section aluminium and are cooled by passing water through a ½-in. diameter hole in the centre of the conductor. The coils weigh 30 tons each. The magnet will produce a field of at least 18,000 gauss at an input power of 840 kW. The cyclotron is surrounded by a concrete wall 6 ft. thick. Additional screening is effected by means of a bank of pulverized sandstone 15 ft. thick. A concrete wall of at least 12 ft. effective thickness, part of which will be constructed in removable blocks of loaded concrete, will separate the cyclotron from the experimental room. Easy access will be provided by means of a 30-ton cylindrical door which may be raised or lowered as required. Above the cyclotron room and separated from it by a concrete roof 5 ft. thick is the equipment room which will house most of the auxiliary gear. The control room will be situated in the main laboratory block.

R. HUBY

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ROYAL GREENWICH OBSERVATORY

ANNUAL REPORT

THE report of the Astronomer Royal to the Board of Visitors of the Royal Greenwich Observatory, presented at the annual visitation of the Royal Observatory, held on June 3, refers to the period from May 1, 1949 to April 30, 1950, and exhibits the state of the Observatory on the latter date. Although a certain amount of progress has been made, things are still far from satisfactory, and the public should realize the serious difficulties under which the Royal Greenwich Observatory is struggling at present.

The temporary repair to the two large domes by placing tarpaulin inside them is only a partial success, and rainwater is able to percolate. The famous Octagon Room, Flamsteed's observatory, is without glass and requires a considerable amount of internal repair; meanwhile, further deterioration is taking place in historic buildings—a condition of affairs which has given rise to much adverse comment. Equally unsatisfactory are the housing conditions for the staff at Herstmonceux. Although the council houses made available through the Ministry of Health are sufficient for the needs of the junior and industrial staff, they are unsuitable for the senior staff, and the lack of houses for the latter is a serious handicap to recruitment for senior grades. It is pointed out that the only solution is for the Admiralty to build houses which are suitable to the status of the officers concerned. The proposal has been made to the Admiralty that houses should be built for the senior observing staff, who could thus reside fairly close to the Observatory; but unfortunately no decision has yet been given on the proposal. This is a matter of grave urgency, and, unless it is attended to forthwith, the work of the Royal Greenwich Observatory will be very seriously handicapped.

In addition to these drawbacks to the personnel, there is great disappointment at the slow rate of progress in the construction of new buildings for the instruments at Herstmonceux, and delays in this work are partly due to the remarkable decision that detailed requirements for every new building must be known before the construction of one of them can be commenced. A ray of hope illuminates a doubtful future—if these delays are not cumulative in their effect and if the new construction (when it commences) is sufficiently accelerated, the whole of the removal to the new site will be completed by the end of 1953.

Among a number of satisfactory features may be mentioned the move of the Solar Department and also, in part, the section of the Magnetic and Meteorological Department which was at Greenwich, and of the Nautical Almanac Office from Bath. The adaptation of the Great Hall of the Castle as a library is making good progress, and the conversion of the permanent chronometer rating and storage rooms under the Great Hall has been completed, the rooms now being in use.

It is impossible in the limited space available here to deal in detail with the report, which should be read by all who are interested in the future of the Royal Greenwich Observatory, and many will be specially interested in the plans for the installation of the Meridian Group and also the Equatorial Group. The latter will have three isolated domes for the 26-in., 28-in. and astrographic refractors, a three-dome building being in front of them to take the

30-in. and 36-in. reflectors as well as a Schmidt camera of 25–38 in., together with an aluminizing room and plant, and various other equipments. The aluminizing plant will be able to deal with the three main mirrors and, in addition, will serve as a pilot-model for the large reflector that will be later required for the Isaac Newton Observatory.

One point which is of special interest is the annual variation in the rotation of the earth, and this is dealt with under "Time Service". The rotation is such that the earth is slow in the spring and fast in the autumn, relative to the uniform time, by about 0·06 sec.; this subject is dealt with very fully by H. F. Finch[1]. The amplitude appears to be practically constant from year to year, and corrections for the effect are being made in the retrospective assessment of clock performance and also in the prediction of clock error and rate for the current operation of the time service.

In spite of the delay in the removal of the Observatory to Herstmonceux, perhaps its completion by the end of 1953, considering the international situation, will be accepted as something for which astronomers may, after all, be grateful.

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SOUTH AFRICAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

ANNUAL REPORT FOR 1948-49

THE fourth annual report of the South African Council for Scientific and Industrial Research* covers the year ending October 5, 1949, and includes the balance sheet and income and expenditure statement for the financial year ending March 31, 1949. While the buildings in which the headquarters staff and library and the national research laboratories for physics, chemistry and building have been housed during the past four years have been adapted to provide reasonably good facilities, the Council has now drawn up preliminary plans and estimates for a permanent building on a site offered by the University of Pretoria on its experimental farm.

Forty-three investigations, on contract, mainly industrial research, were completed during the year, and the system of industrial research fellowships has received further support. In addition to two research fellowships on lightning problems, two fellowships for the chemistry of wool and its by-products are being provided by the South African Wool Board. The Council also assisted in the incorporation of the Paint Industries Research Institute and the Sugar Milling Research Institute, and has discussed with the South African Wool Board the establishment of a wool textile research institute under its research association scheme. Satisfactory progress is also reported by the Fishing Industry Research Institute and the Leather Industries Research Institute. Of £46,130 provided by the Council for research workers in the universities and medical research units, £18,680 was for research in clinical medicine and surgery.

Special stress is laid in the report on the importance of the medical research units. Such units have been developed for research on tuberculosis, amœbiasis, bilharziasis and tropical diseases, nutrition, virus diseases, social medicine and cardio-pulmonary disease. A subcommittee of the Medical Research Committee advises the Council on the medical applications of radioisotopes, and the new new drugs, 'Miracil D' and 'aureomycin', have received attention from the Bilharziasis and Amœbiasis Research Units, respectively. The Library and Information Division continues to be handicapped by lack of sets of standard scientific periodicals. A special member of the staff has now been appointed to deal with requests for information, and the Division has also compiled a list of translators for scientific and technical work and organised a second one-day school of library methods for workers in small technical libraries.

The work of the National Building Research Institute has centred on four major problems to the solution of which all the more fundamental investigations have been directed. These are the provision of urban housing for Africans, building on the desiccated clay soils of the high veldt, the gain and loss of heat in buildings under high-insulation conditions, and problems associated with the use of high-magnesium limes. In the National Chemical Research Laboratory a study has been made of the constitution of South African clays, especially those being used to replace bentonite in foundry sands, of the dissolution of Transvaal chromite in sulphuric acid and the electrowinning of chromium, the colorimetric determination of citric acid with the Spekker absorptiometer, the submerged production of citric acid and the application of the anaerobic or methane fermentation process to the purification of molasses fermentation and wine distillation residues. Field research work carried out by the National Institute for Personnel Research has further increased, and much time has been given to research and routine testing on behalf of the Department of Defence. A Psychophysiological Research Unit was formed during the year, and the Statistical Section has worked out a new method of calculating standard scores which is applicable even to grossly abnormal distributions.

Most of the sections of the National Physical Laboratory are now well equipped and are capable of carrying out both applied and fundamental research. In the Electrotechnology and Electronics Division an instrument was developed for measuring and recording the thermocouple voltages generated in the differential thermal analysis of clays and the sine-wave generator brought to completion, while the construction of a saturated-diode transfer standard is nearly completed and a quantometer is being developed for use in spectro-chemical work. The Physics of Matter Division is developing a scintillation assay meter for the assay of uranium oxide in acid solution; a kevatron particle accelerator is receiving a trial run, and an X-ray spectrometer has been modified and fitted with a new slit-system to handle clay minerals with large basal spacings. A high-temperature camera has been designed and built, and a recording spectrophotometer installed. Considerable attention has been given to lens designing. The Telecommunications Research Laboratory has concentrated increasingly on the factors affecting radio-wave propagation in southern Africa, including the ionosphere, radio noise-levels and the physical constants of the ground. Other work includes the development of a high-performance communications receiver on a new principle, the development of an automatic weather station, the study of thunderstorms by radar, and lightning research.

* South African Council for Scientific and Industrial Research. Fourth Annual Report, 1948–1949. Pp. 84 + 7 plates. (Pretoria: South African Council for Scientific and Industrial Research, 1950.)

LETTERS TO THE EDITORS

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A Reported Photosynthesis *in vitro*

NUMEROUS attempts to achieve a photo-sensitized reduction of carbon dioxide by water *in vitro* are on record[1]. Various degrees of success have been claimed; but in almost every case the repetition of such experiments in other laboratories has failed and, in any event, the yields originally reported were extremely small. A significant advance, however, appeared to have been made in 1943 by Baur and his co-workers[2]. After many years of experimentation, Baur developed a two-phase system consisting of glycerol, geraniol, chlorophyll and methylene blue, which on illumination in a carbon dioxide atmosphere was stated to produce formaldehyde and oxygen in a photochemical yield amounting to about 5 per cent of that of natural photosynthesis. Although it is now known that formaldehyde is not an intermediate in natural photosynthesis, the realization of a photo-sensitized hydrogen-transfer reaction between carbon dioxide and water outside the living cell would be a result of great significance, and a confirmation of Baur's results, which have been widely quoted, therefore appeared desirable.

The experimental details given in Baur and Niggli's paper are not precise, but an attempt has been made to reproduce the conditions as closely as possible. Our reaction mixture consisted of 30 ml. of glycerol, 15 ml. of geraniol, 30 mgm. of crystalline chlorophyll and 18 mgm. of methylene blue. Baur and Niggli make no reference to the provision of water in their system, and it must be presumed that they relied on the water content of commercial glycerol. Our own sample of glycerol contained 1 per cent w/v of water as determined by titration with Karl Fischer reagent. Since commercial geraniol contains an appreciable proportion of aldehydic material, particularly citral, which is difficult to remove by fractionation and might interfere in the detection of formaldehyde, an aldehyde-free sample was prepared by suitable treatment with lithium aluminium hydride[3]. (The geraniol sample obtained after distillation had n^{15}_D 1·4758. Barnard *et al.*[4] give n^{15}_D 1·4782 for a sample purified through the calcium chloride adduct.) The reaction mixture was placed in a water-jacketed cylindrical 'Pyrex' glass vessel connected to a 1·5-litre gas reservoir and to an all-glass electromagnetic circulating pump. The apparatus was several times evacuated to a pressure of 1 mm. of mercury, and filled with pure carbon dioxide obtained by heating sodium bicarbonate. The cylindrical vessel was then agitated mechanically and illuminated for 24 hours with two 300-watt bulbs provided with metallic reflectors. At the end of this period, the emulsion was extracted with 60 ml. of water and the aqueous layer was treated with charcoal and filtered to give a colourless solution.

In agreement with Baur and Niggli, this filtrate gave a positive result with ordinary Schiff's reagent, and comparison with dilute aqueous formaldehyde solutions treated in the same manner showed that the intensity of the violet coloration corresponded to the presence of about 2 mgm. of formaldehyde in the aqueous extract. However, in contrast to the authentic formaldehyde solutions, the aqueous extract failed to give a positive result with strongly acid Schiff's reagent[4] or in the chromotropic acid test[4]. Furthermore, the aqueous extract yielded a 2 : 4-dinitrophenylhydrazone which could not be completely purified, but which showed an ultra-violet absorption maximum at considerably longer wavelengths (λ_{max} 3680 A. in chloroform solution) than the formaldehyde derivative (λ_{max} 3480 A.)[5]. Baur and Niggli, on the other hand, state that they identified formaldehyde as the dimedone derivative, the melting point of which is not reported.

Although the aldehydic material formed in our experiment is clearly not formaldehyde, it seemed possible that it was perhaps a condensation product of the latter ultimately derived from carbon dioxide. The experiment was therefore repeated in an atmosphere of helium instead of carbon dioxide, under otherwise identical conditions, and the aqueous extract was submitted to the same tests as previously. The results again indicated the formation of an aldehyde other than formaldehyde and in nearly the same quantity as before. It may be concluded that, whatever the nature of the aldehydic product formed in the first experiment, it was not derived from the carbon dioxide but from another component of the reaction mixture. There is therefore no evidence for the occurrence of photosensitized reduction of carbon dioxide in our experiments.

We thank Monsanto Chemicals, Ltd., for a research award to one of us (C. J. T.).

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July 14.

[1] Cf. Rabinowitch, "Photosynthesis", Vol. 1 (Interscience, New York, 1945).
[2] Baur and Niggli, *Helv. Chim. Acta*, **26**, 251 (1943).
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Uracil Deoxyriboside

DURING the isolation of the deoxyribosides of guanine, hypoxanthine, thymine and cytosine from an enzymatic hydrolysate of a commercial preparation of herring sperm deoxyribonucleic acid (Isaac Spencer and Co., Ltd., Aberdeen), a fifth compound was obtained and identified as uracil deoxyriboside.

The new compound was initially found as a contaminant of thymidine isolated according to the method of Brown and Lythgoe[1]. It was tentatively identified on a paper chromatogram by its R_F value (the pyrimidine deoxyribosides have been found to have the same R_F values as their component pyrimidine bases when run on a paper chromatogram with a butanol : water (86 : 14) solvent) and by the slow development of a blue colour when treated with Dische's reagent[2]. Since the occurrence of the uracil deoxyriboside coincided with a marked decrease in the recovery of cytosine deoxyriboside, it was assumed that deamination of the latter compound had taken place, probably by enzymatic hydrolysis. Unequivocal proof that the uracil deoxyriboside had not been present as a constituent of the intact deoxyribonucleic acid was obtained when formic acid hydrolysis of the deoxyribonucleic acid[3] and subsequent chromatography of the hydro-

lysate demonstrated the absence of uracil. The failure to find this new deoxyriboside in either previous or subsequent identically conducted isolation experiments obviated the supposition that one of the enzyme preparations used in the degradation contained a cytosine deoxyriboside deaminase. It was therefore concluded that bacterial contamination had occurred during the preparation by a micro-organism possessing an enzyme capable of deaminating cytosine deoxyriboside. Such an enzyme has recently been found to occur in extracts of cells of a certain strain of *E. coli*[4].

The impure thymidine containing the uracil deoxyriboside was partitioned on a powdered cellulose column using butanol – water. Although this gave a complete separation of the two deoxyribosides, the uracil deoxyriboside thus obtained was still contaminated with 5–10 per cent of uracil. The presence of the latter substance was also noted by Wang *et al.*[4], who found, by means of spectrophotometric measurements, that uracil as well as uracil deoxyriboside was formed when cytosine deoxyriboside was treated with their bacterial cell extract. The uracil, which could not be removed by recrystallization from 90 per cent ethanol, was completely separated from its deoxyriboside by chromatography on a cellulose column with *tert.*-butanol : pyridine : water (65 : 25 : 15). The new deoxyriboside, after recrystallization from 95 per cent ethanol, gave needles or clusters of small needles, melting point 163° (found : C, 47·0; H, 5·3; N, 12·6. $C_9H_{12}N_2O_5$ requires C, 47·3; H, 5·3; N, 12·3 per cent). $[\alpha]_D^{22} + 50°$ ($\pm 2°$) (*c*, 1·1 in *N* NaOH). The solubility of uracil deoxyriboside in water and alcohol is very similar to that of thymidine. The ratio, R_F uracil deoxyriboside/R_F thymidine, is 0·74 in butanol : water (86 : 14), 0·94 in *iso*propanol : 2*N* hydrochloric acid (65 : 35), 0·94 in *tert.*-butanol : pyridine : water (60 : 25 : 15), and 0·83 in butanol : acetic acid : water (20 : 5 : 25). Formic acid hydrolysis of the deoxyriboside and paper chromatography of the hydrolysate in several different solvents gave, in each case, only one ultra-violet absorbing spot[5] having an R_F value identical with that of uracil.

A second commercial preparation of deoxyribonucleic acid (Schwarz Laboratories, Inc., New York), which on formic acid hydrolysis produced a considerable amount of uracil[6], was found to contain uracil deoxyriboside after enzymatic hydrolysis. Paper chromatography of a 95 per cent ethanol extract of the lyophilized enzymatic hydrolysate gave three distinct spots with butanol : water. The slowest-moving spot proved to be primarily cytosine deoxyriboside with traces of guanine and hypoxanthine deoxyribosides. Smith and Cuthbertson[7] have shown that these three deoxyribosides have very similar R_F values in water-saturated butanol[1]. The fastest-moving component proved to be thymidine, and the intermediate spot was uracil deoxyriboside plus a small amount of adenine deoxyriboside. This latter fact was demonstrated by paper chromatography of the middle component using *iso*propanol : 2*N* hydrochloric acid (65 : 35). The uracil deoxyriboside was separated as before, and was shown to have the same R_F value in *iso*propanol : 2*N* hydrochloric acid as the compound obtained from the bacterially contaminated hydrolysate of herring sperm deoxyribonucleic acid and as the product of nitrous acid deamination of cytosine deoxyriboside. In view of the absence of uracil in the large number of specimens of deoxyribonucleic acid analysed by Chargaff and co-workers[8-10] and by Wyatt[11], it is believed that the uracil present in this deoxyribonucleic acid was formed from cytosine in the course of the preparation of the commercial product. Confirmation of this partial degradation was found in the low yields of cytosine obtained on formic acid hydrolysis and in the incomplete hydrolysis (60 per cent) of the preparation when treated with deoxyribonuclease and nucleophosphatase.

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* Fellow of the American Cancer Society, recommended by the Committee on Growth, National Research Council.

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Autoxidation of Oleic (or Other Monoethenoid Long-Chain) Esters

It is generally accepted that autoxidation of unsaturated fatty compounds at ordinary temperatures is an action propagated by a free-radical mechanism. The radicals concerned have been shown to be derived from the α-methylenic groups adjacent to a double bond. From consideration of chemical and kinetic evidence Bolland[1] has concluded that the chain propagation reactions involved are

$RO_2— + RH \rightarrow R.OOH + R—$ and $R— + O_2 \rightarrow RO_2—$,

where *RH* is an unsaturated fatty ester, and *R*— is a free radical of the formula $R'.\dot{C}H.CH = CH.R''$.

The *initiation*, as distinct from *propagation*, of the autoxidation reaction has been the subject of some discussion; but Farmer[2] considered that "there is perhaps good justification for postulating universal *initiation* of autoxidative attack in all the various kinds of olefinic systems by *addition* occurring at double bond centres", for example,

$$.CH_2.CH : CH. \xrightarrow{O_2} .CH_2.\dot{C}H.CH(OO^{\bullet}) \xrightarrow{.CH_2.CH : CH} CH_2.\dot{C}H.CH(OOH) + .\dot{C}H.CH = CH.$$

Gunstone and Hilditch[3] concurrently put forward the view that initial interaction between oxygen and an ethenoid bond is more likely than direct initial hydroperoxide formation at a methylene group; initial loose attachment of oxygen at a double bond could result in migration of a hydrogen atom from an α-methylenic group with formation of a hydroperoxide and consequent 'displacement' of the double bond:

$$.CH : CH.CH_2 \xrightarrow{O_2} .CH.\dot{C}H.CH_2. \rightarrow .CH.CH = CH.$$
$$\qquad\qquad\quad | \qquad\qquad\quad |$$
$$\qquad\qquad\quad O_2 \qquad\qquad\quad OOH$$
$$\qquad\qquad\quad |^{\bullet}$$

The object of this note is to suggest that, at ordinary temperatures, initiation of autoxidation is a function solely of long-chain unsaturated compounds which contain the pentadiene system .CH : CH.CH_2.CH : CH., with a central reactive methylene group; and that the simple mono-ethenoid system .CH_2.CH : CH.CH_2. is not susceptible to similar direct attack by oxygen at temperatures below about 50° C. (although at higher temperatures direct union between oxygen and a mono-ethenoid ester such as methyl oleate proceeds rapidly[4,5]).

Reasons for this conclusion are: (1) the marked resistance of the methyl oleate used by Gunstone and Hilditch[3,5] to autoxidation as compared with that used by previous workers; (2) the circumstance that the oleate used by Gunstone and Hilditch was prepared by new methods which ensured complete absence of linoleate, as shown by spectroscopic evidence; (3) and their observation[3] of the marked effect of very small proportions of added linoleate (1 per cent or less) in reducing the initial 'induction period' for this methyl oleate in diffused daylight at 20° by about 80 per cent (from about 800 hours to 150 hours).

On the other hand, the methyl oleate used by Atherton and Hilditch[4], and prepared by older methods, contained about 5 per cent or somewhat less of linoleate, and that employed by Farmer and Sutton[6] (probably also containing some linoleate), in the course of the isolation of methyl oleate peroxide, absorbed oxygen with relatively great rapidity at 35° with ultra-violet irradiation, the product after autoxidation for 4 hours containing 1·3 per cent of peroxide oxygen. It has since been found by Dunn and Riley (unpublished experiments from these laboratories) that the linoleic-free methyl oleate referred to above absorbs oxygen relatively very slowly at 20–25° when exposed to oxygen in the light of an ultra-violet lamp in the manner of Farmer and Sutton's autoxidations; moreover, the similar autoxidation of methyl ricinoleate or of methyl undecenoate (both of which are relatively easily freed from linoleic or other polyethenoid admixture) was found to be extremely slow.

Taken in conjunction, all these at first sight divergent observations suggest strongly that methyl oleate free from contamination with linoleate had not been employed in autoxidation studies prior to the experiments described by Gunstone and Hilditch; and that, to all intents and purposes, methyl oleate, when free from linoleate, does not undergo autoxidation at ordinary temperatures. Further, since it has been shown[3] that autoxidation of pure oleate can be readily induced in presence of a small proportion of linoleate, it is clear that, although initiation of the process does not take place with oleate alone, the chain reaction can be propagated freely so soon as active peroxide radicals, derived *initially* from linoleate, are present in sufficient amount.

The course of the oxidation of the oleate groups is thus conditioned solely by the chain propagation reaction, and may well, therefore, be exclusively that of the formation of hydroperoxide groups at the α-methylenic groups adjacent to the double bond:

$$.CH_2.CH : CH.CH_2. + R.OO \rightarrow .CH_2.CH : CH.CH(OOH). + R—$$

(where *R*H is initially methyl linoleate, but may afterwards also be methyl oleate).

It has seemed appropriate to direct attention to these features in previously recorded autoxidation studies of methyl oleate, since the explanation now offered not only clarifies somewhat divergent observations, but also points to a major difference in behaviour to oxygen (as might be expected) between the isolated mono-ethenoid system —CH_2.CH:CH.CH_2— and the pentadiene grouping —CH:CH.CH_2.CH:CH— with its 'reactive' central methylene group.

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Aug. 30.

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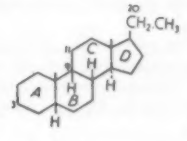
Structure of Uranediol

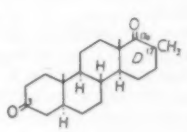
Marker and his colleagues[1] isolated in 1938 from the urine of pregnant mares two compounds, uranediol ($C_{21}H_{36}O_2$) and uranetriol ($C_{21}H_{36}O_3$), which were derivatives of a hydrocarbon urane, isomeric with pregnane and apparently steroid in character. Uranediol has since been isolated from pregnant mare's urine by Bauld and Heard[2] and by Klyne[3].

Marker[1b,c] suggested that urane was 9-*iso*-pregnane (I) and that the hydroxyl groups of the diol and triol were at positions 3 and 11, and 3, 11 and 20 respectively, but was unable to prove these hypothetical structures. The compounds are of interest since they are the only naturally occurring steroids for which a *cis* union of rings *B* and *C* has been postulated, except for sarmentogenin, now known to have the usual *trans* *B*/*C* fusion[4].

It has now been shown that uranediol also has the usual *trans* *B*/*C* fusion, but is a *D*-homosteroid. It appears to be the first such compound of natural origin to be isolated.



I



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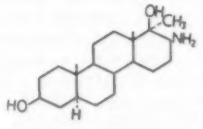

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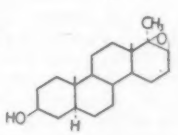
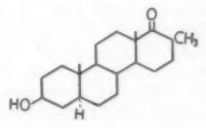


IV



V

In June 1949 it occurred to me that the properties of the urane compounds could best be accounted for by their formulation as 17-methyl-*D*-homoandrostane derivatives, uranedione being the 3 : 17*a*-diketone (II). This formula accounts for the molecular rotation[2], infra-red absorption[3] and the presence of one hindered keto group which does not form a semicarbazone[1c,3]. Attempts to synthesize the structure II were begun.

Recently, I noticed that a compound "XI", $C_{21}H_{34}O_3$ (obtained by Prins and Shoppee[6] by treatment of the amine III with nitrous acid, and formulated by them as the epoxide IV because it did not react with Girard's reagent *T*), resembled closely Marker's uran-3-ol-11-one[1d]. The properties of Prins and Shoppee's compound "XI" seemed compatible with its formulation as a hindered ketone V. If this idea and the previous hypothesis regarding urane compounds were correct, oxidation of "XI" with chromium trioxide should give uranedione (II).

Prof. C. W. Shoppee very generously gave me 20 mgm. of the compound "XI", which was oxidized with chromium trioxide in glacial acetic acid at room temperature. The product was identical with uranedione obtained by oxidation of uranediol[3], as shown in the accompanying table.

COMPARISON OF THE OXIDATION PRODUCT OF COMPOUND "XI" AND URANEDIONE

	Oxidation product of compound "XI"		Uranedione
M.p.*	173–176°	174–176°	171–174°
Mixed m.p.			
$[\alpha]_D$ in chloroform	−23·0 ± 1·0°		−21·3 ± 0·9°
Semicarbazone, m.p.	221–224°		223–227°
Semicarbazone, mixed m.p.		221–225°	
Semicarbazone, N content†	11·0 per cent		12·1 per cent

* All melting points are corrected. The semicarbazone melts with decomposition.
† A monosemicarbazone requires N 11·2 per cent; a disemicarbazone requires N 19·5 per cent.

The presence of a keto-group in Shoppee's compound "XI" was confirmed by the ultra-violet absorption spectrum, which showed a low maximum at 290 mμ.

From the evidence given above it is clear that compound "XI" is, in fact, a hindered ketone and can only have the formula V. Uranedione must therefore be II. Attempts to synthesize II by an independent route are being continued.

Since uranedione is stable to acid[3], the methyl group at C-17 is presumably in the stable equatorial position, 17α (cf. Barton[7]). Since uranediol can be precipitated by digitonin, the hydroxyl group at C-3 is most probably β-oriented. Uranediol is therefore a 17-methyl-*D*-homoandrostane-3 : 17*a*-diol, most probably a 17α-methyl-3β-hydroxy isomer, the orientation of the 17*a* hydroxyl being unknown.

Since uranediol has been isolated[3] from mare's urine as its sulphuric acid ester by relatively mild procedures, it seems unlikely that it is an artefact. (Contrast the *D*-homosteroid obtained by Hirschmann and Hirschmann[8] from the urine of a boy with adrenal carcinoma; these authors state that the *D*-homo compound was probably produced by rearrangement during the fractionation of the extract.) Uranediol appears, therefore, to be the first *D*-homosteroid of natural origin to be isolated.

I am indebted to the Agricultural Research Council for a grant for expenses.

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July 25.

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Absorption Spectra of the Sodium Peruranates

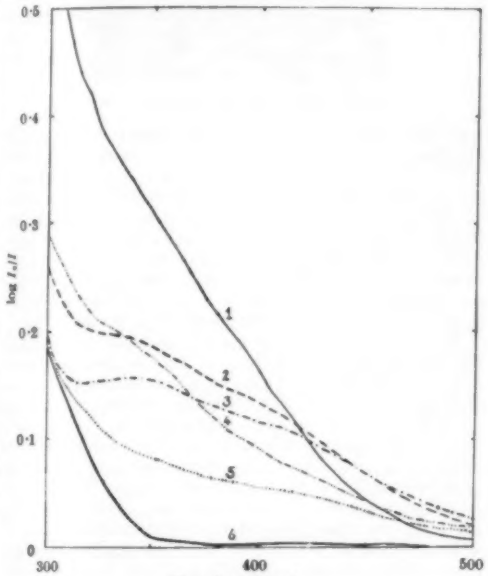
IT was shown by Scott[1] that the presence of bicarbonate in solutions of sodium peruranate, formed by the addition of excess hydrogen peroxide to sodium uranyl tricarbonate solution, caused errors in the absorptiometric determination of uranium. Smales and Furby[2] found the optical density to be dependent on both the *p*H and the carbonate content of the solutions. A study of the absorption spectra of these solutions, using the Beckmann spectrophotometer, confirms the theory of Scott that the colour change is due to the formation of a series of peruranates, and suggests that his alternative mechanism, the formation of sodium uranyl tricarbonate as a result of the action of sodium bicarbonate, is less important.

When uranium dioxide is shaken with an excess of sodium carbonate solution in the presence of hydrogen peroxide, the maximum quantity dissolved is 0·33 mol. UO_3/mol. H_2O_2. This observation suggests the formation of Na_4UO_6, as the predominating constituent of the solution, by the reaction:

$$UO_3 + 3H_2O_2 + 2Na_2CO_3 = Na_4UO_6 + 2H_2O + 2NaHCO_3.$$

The addition of excess sodium hydroxide and hydrogen peroxide to the solution results, after concentration and cooling, in the formation of orange-red needle crystals which have been shown to be sodium peruranate, $Na_4UO_6.8H_2O$. This compound is apparently identical with those prepared by Fairley[3], and by Rosenheim and Daehr[4]. Curves 1, 2, 3 and 4 are typical of the absorption spectra of solutions of uranium trioxide in (1) sodium carbonate and excess sodium hydroxide, (2) sodium carbonate, (3) equal quantities of sodium carbonate and sodium bicarbonate, and (4) sodium bicarbonate, a large excess of hydrogen peroxide being present in each case. Curve 1 thus represents the absorption spectrum of a solution in which Na_4UO_6 predominates. Curves 2 and 3 are progressively less steep than curve 1, the density increasing in the region 420–500 mμ, although sodium uranyl tricarbonate solution (curve 6) shows little absorption in this region. Solutions 2 and 3 must therefore contain peruranates lower than Na_4UO_6, the observation on the solution of uranium dioxide suggesting that these solutions contain high proportions of Na_2UO_6. The further addition of sodium bicarbonate causes a reversal of the trend shown by curves 2 and 3, curve 4 being steeper, and showing little trace of the absorption maximum at 340 mμ which appears

to be characteristic of the compound Na_4UO_5. This curve must therefore represent the spectrum of a solution in which the lowest peruranate, considered by Rosenheim and Daehr to be $Na_4U_2O_{10}$, predominates. It would thus appear that the changes in the absorption spectra of sodium peruranate solutions containing varying proportions of sodium hydroxide, sodium carbonate and sodium bicarbonate, with excess hydrogen peroxide, are due largely to changes in proportion of the three peruranates, the effect of absorption by sodium uranyl tricarbonate being relatively unimportant.



UO_2 0·005 per cent w/v in all solutions. 1-cm. cells.
Curve 1. Na_2CO_3, 0·125; NaOH, 0·40; H_2O_2, 0·06% w/v.
Curve 2. Na_2CO_3, 0·125; H_2O_2, 0·06% w/v.
Curve 3. Na_2CO_3, 0·125; $NaHCO_3$, 0·125; H_2O_2, 0·06% w/v.
Curve 4. $NaHCO_3$, 0·125; H_2O_2, 0·06% w/v.
Curve 5. Na_2CO_3, 0·125; H_2O_2, 0·0003% w/v.
Curve 6. Na_2CO_3, 0·125% w/v.

This hypothesis is confirmed by a study of the spectrum of a solution of uranium trioxide in sodium carbonate, with insufficient hydrogen peroxide to form the lowest peruranate. The resulting curve (curve 5), which is characteristic of a mixture of sodium uranyl tricarbonate and sodium peruranate, is intermediate in form between curves 3 and 6, and shows little resemblance to curve 4. Solution 4 cannot therefore contain a similar mixture, but must be composed largely of the lowest peruranate, $Na_4U_2O_{10}$.

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Nature of Specific Solvents for Bituminous Coals

In previous communications[1] it has been pointed out that certain liquids—termed specific solvents—possess a marked ability to dissolve bituminous coals of low rank at room temperature, a property not shared by other liquids; furthermore, almost all liquids tested have been found to fall *definitely* into one or other of these classes. The principal specific solvents are primary aliphatic and certain heterocyclic amines.

A comparison of the solvent power data for more than a hundred substances has now shown that this property bears very little relation to the internal pressure, surface tension, dielectric constant or dipole moment of the solvent. The significance of the moderate correlation with internal pressure observed by Kiebler[2] has already been discussed[1]; it is probable that it reflects conditions under which, owing to incipient pyrolysis of the coal, nearly all organic liquids are moderately effective 'solvents' and specific factors are less important.

At atmospheric temperature, on the contrary, the following rules have emerged. The specific solvent (for example, an aliphatic primary amine) contains a nitrogen or oxygen atom with an unshared pair of electrons. This electron pair, however, may be prevented from promoting solvent power by interfering influences: (1) by excessive hydrogen bonding, for example, in amines when diluted with water, or in ethylene glycol as contrasted with ethylene diamine; and (2) by participation of the lone pair in resonance of the molecular nucleus, for example, in aniline and pyrrole as contrasted with benzylamine and pyridine. Other things being equal, nitrogen compounds are better solvents than compounds containing oxygen (compare the primary amines with alcohols, which are very weak in solvent power). Alkyl groups in themselves tend to reduce solvent power; this can be seen from the fact that diethylamine is one of the most effective precipitants for removing coal extracts from solution in specific solvents, and is an important factor determining the lack of solvent power of secondary and tertiary aliphatic amines. The inability of secondary and tertiary amines to swell coal remains to be explained. The adverse effect of alkyl groups in primary aliphatic amines is insufficient to remove these from the ranks of specific solvents; when comparison is made with primary aromatic amines, in which the adverse influence of resonance is pronounced, alkyl groups therefore appear at first sight to promote activity. Solvent power is further modified by such factors as molecular size, viscosity, and by inductive effects which influence the availability of the unshared pair.

It is perhaps worth while emphasizing the contrast between the behaviour of solvents towards an 'aged' or compacted gel system such as coal[3] (in which the primary function of a solvent must be to swell and so loosen the structure), and towards such natural and synthetic polymers as have not been subjected to comparable treatment; and also between systems (for example, coal and amines) in which specific interaction occurs, and those (for example, rubber and benzene) at the opposite extreme, in which both compounds have a chemical similarity and interaction takes place through van der Waals forces. An appreciation of these differences serves to explain why many well-known relationships[4] and approximations[5] can have little relevance to the phenomena of coal solution.

SINCE the preceding was written, a paper by Dilke, Eley and Sheppard[6] on the mechanism of the Friedel–Crafts reaction has appeared, which raises further points of interest. These workers have used the heat of interaction of various amines with aluminium chloride as an approximate measure of the co-ordinate bond-energy. By this criterion, amines fall into the same relative order as that found when they are arranged according to their ability to swell and dissolve lower-rank bituminous coals, thus providing further confirmation of the conclusion that an electron-donor mechanism is involved in the interaction between these coals and amines. Particularly striking is the great difference between primary, secondary and tertiary aliphatic amines, which was also observed by Brown[7] in the case of their interaction with tributyl boron. Brown attributes this behaviour to steric interference between groups attached to the electron acceptor and to the donor respectively, emphasizing that the steric factor must involve a contribution from *both* sides[8]. The observations with coal therefore indicate that the electron acceptor on coal surfaces is surrounded by alkyl or other groups projecting from the surface. Inertness of secondary and tertiary aliphatic amines (as with coal) was observed by Brown[7] only when (the large) *butyl* groups were attached to the boron; but in this case ammonia was the most active base, whereas with coal it is not; trimethyl boron, on the other hand, removes ammonia to a lower position while retaining the same order for the amines, but secondary and tertiary amines in this case form weak addition compounds. A complete explanation of the results with coal is therefore not yet forthcoming.

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Hydrothermal Synthesis of Potash Feldspar in the Range 195–200° C.

CONSIDERABLE interest is attached to conditions under which syntheses of feldspars may be accomplished. A number of preparations have been described by high-temperature sintering[1–3], pneumatolytic[4], or pyrolytic[5] methods, and at lower temperatures by the hydrothermal procedure[6–9], the usual range of temperatures lying between 300° and 1,000° C. The lowest temperature previously recorded for such a synthesis has been 245° C. in the case of Gruner's formation of potash feldspar, by hydrothermal alteration of montmorillonite[9]. The reaction at this temperature was, however, very slow and required about six weeks.

We now record a synthesis of potash feldspar, which gave a high yield within sixteen hours in the temperature interval 195–200° C. Synthetic leucite ($KAlSi_2O_6$), sodium and potassium carbonates and water were mixed and introduced into a steel autoclave of 20 c.c. internal capacity. Sufficient of each

Crystal of synthetic potash feldspar (× 1,400)

salt was present to give a saturated solution and an excess of the solid salt. After heating at 195–200° C. for sixteen hours the product was transferred to a filter paper, washed thoroughly and dried at 90° C. The crystals were small, of refractive index 1·521, as with orthoclase, and gave good X-ray powder photographs identical with those from naturally occurring orthoclase and adularia. The accompanying figure shows a typical crystal, which is seen to be of a form characteristic of orthoclase.

This formation represents a complete synthesis of potash feldspar, since the leucite was prepared from analcite ($NaAlSi_2O_6.H_2O$) and the analcite was grown directly from a hydrous sodium aluminosilicate gel of approximately analcite composition. The gel was made from 'Alfloc' ($NaAlO_2$ + some free alkali) and silicic acid gel free from entrained acid. It was crystallized hydrothermally at about 200° C., the reaction normally being completed overnight. The analcite was then treated hydrothermally at 150° C. with saturated potassium chloride (aq.) containing some solid potassium chloride crystals, four successive treatments being given. The analcite was in this way subjected to complete ion exchange to give synthetic leucite:

$$\underset{\text{Analcite}}{NaAlSi_2O_6.H_2O.} + K^+aq. \rightarrow \underset{\text{Leucite}}{KAlSi_2O_6} + Na^+aq. + H_2O.$$

The leucite was then available for conversion to potash feldspar as described.

The conversion serves as a reminder that geochemical processes often regarded as comparatively high-temperature ones can sometimes be easily accomplished in the laboratory under quite mild conditions. In this and probably in similar cases one may extend geological experience by direct chemical methods.

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Rotation-Vibration Spectrum of the HD Molecule

As is well known, the hydrogen molecule (H_2) has no ordinary dipole infra-red spectrum. Its quadrupole rotation-vibration spectrum is exceedingly weak, and has only recently been found[1]. In the case of HD, on account of the asymmetry, there is no longer a distinction between symmetric and antisymmetric rotational levels, and a dipole rotation-vibration spectrum can occur at least in principle. However, the change of dipole moment associated with the vibration of HD is obviously very small. The main contribution to this change is due to the fact that the electrons lag slightly behind the nuclei during the vibrational motion. Wick[2] has calculated according to wave mechanics the intensity of the fundamental of HD. From his data it can be estimated that the minimum absorbing path required for an observation of the fundamental of HD is 30 m. atm. For the overtones, correspondingly longer path-lengths would be required.

With the technique of long optical paths recently developed[3], it appeared promising to attempt an observation of the HD spectrum in the photographic infra-red. A glass absorption tube 5 metres long was filled with HD of 1 atm. pressure. Using approximately 140 and 200 traversals, that is, absorbing paths of 700 and 1,000 metres, seven and six lines respectively were found of the 3–0 and 4–0 bands of HD (second and third overtone) near 9650 and 7400 A. The accompanying table lists the observed wave-numbers. Even with the long path used, the intensities of the HD lines are quite low. The over-all intensity of the 4–0 band of HD is lower than that of the 3–0 band by a factor of only 3 or 4. This is noteworthy, since for ordinary dipole vibration spectra the intensity ratio of the second and third overtone is of the order 30 or 40 (for example, for hydrogen chloride).

HD Absorption Lines

Designation		ν_{vac} (observed)	$o-c_1$	$o-c_2$
3–0	$R(0)$	10445·536	+ 5·325	−0·004
	$R(1)$	10511·488	+ 5·771	−0·009
	$R(2)$	10565·048	+ 6·474	+0·008
	$R(3)$	10605·764	+ 7·403	+0·010
	$P(1)$	10278·419	+ 5·091	−0·015
	$P(2)$	10178·467	+ 5·340	+0·015
	$P(3)$	10068·351	+ 5·748	−0·009
4–0	$R(0)$	13551·127	+ 7·118	+0·008
	$R(1)$	13609·745	+ 8·203	+0·006
	$R(2)$	13652·293	+ 9·813	−0·012
	$R(3)$	13678·435	+11·986	−0·003
	$P(1)$	13387·695	+ 6·575	+0·007
	$P(2)$	13284·020	+ 7·095	−0·012

The best available rotational and vibrational constants of HD in the $^1\Sigma^+$ ground-state are those calculated from the constants of H_2 by Jeppesen[4] and Urey and Teal[5]. The constants obtained directly from the ultra-violet HD spectrum are less accurate (see Jeppesen[4]). Using Urey and Teal's constants, the positions of the HD lines can be predicted. Column 3 of the table gives the differences between these predicted and the observed wave-numbers. It is seen that there is a systematic difference, principally due to the fact that the original H_2 constants from which the HD constants were calculated need revision[1]. The following rotational and vibrational constants of HD were derived directly from the observed wave-numbers combined with the Raman data of Teal and MacWood[6]:

$$B_v = 45{\cdot}638_3 - 1{\cdot}9503(v+\tfrac{1}{2}) + 0{\cdot}0140_6\,(v+\tfrac{1}{2})^2.$$
$$D_v = 0{\cdot}02590 - 0{\cdot}00084(v+\tfrac{1}{2}) + 0{\cdot}00004_4\,(v+\tfrac{1}{2})^2.$$
$$G(v) = 3809{\cdot}7_{46}(v+\tfrac{1}{2}) - 89{\cdot}7668(v+\tfrac{1}{2})^2 + 0{\cdot}36567(v+\tfrac{1}{2})^3.$$

A value $H_v = 0{\cdot}0000219$ cm.$^{-1}$ was assumed. The differences between the observed wave-numbers and those calculated from the new constants are given in the last column of the table.

If a sufficient amount of hydrogen and deuterium were present in the atmospheres of the major planets, the 4–0 band of HD might be used for their detection[7]. However, this would require the highest possible resolution, because of the small width of these lines.

It is hoped to observe the fundamental and first overtone of HD in the near future with the aid of a new high-dispersion infra-red spectrometer which is being built in this laboratory.

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A New Type of X-Ray Scattering

Insulators are characterized by discrete allowed and forbidden zones having sufficient energy width. In diamond, theoretical calculation by Kimball[1] shows that the forbidden zone width is about 7 eV., which has been experimentally verified by the appearance of the ultra-violet absorption band[2] at 1700 A., that is, 7 eV. I have determined the forbidden zone widths in the case of the insulators aluminium oxide and silica from their soft X-ray absorption and valence emission spectra[3]. Skinner[4] has investigated beryllium, carbon and boron in the conducting state, as well as in the insulators beryllium oxide (BeO), diamond and boron trioxide[5]. Siegbahn[6] has investigated K_α of diamond, as well as that of graphite, the conducting variety. E. Guinner and H. Kiessig[7] have investigated K_α, that is, K valence band spectra of boron in the pure element, in various binary alloys and in boron trioxide, which is a typical insulator. I have investigated K valence band spectra of the insulators aluminium oxide and silica.

In all the elements beryllium, boron, carbon (graphite), silicon and aluminium and in all their conducting alloys, the long wave-length K valence band satellite is absent. But in typical insulators involving these elements, there appears a long wave-length satellite which is most prominent in the case of beryllium oxide, boron trioxide and diamond, for which the characteristic X-ray wave-lengths concerned are only the K_α-radiation of metal and of oxygen. The energy gap between the peak of the long wave-length satellite and the main K_α-band for these insulators agrees well with the energy difference between the peak of the valence emission band and the approximate centre of the first allowed vacant band obtained from the absorption data.

The explanation is as follows: K_α of beryllium, boron and carbon produced by electron impact

within the sample of beryllium oxide, boron trioxide and diamond, while coming out of the thin layer of the insulator in the target, is partially absorbed by the valence electrons of the particular insulator. These electrons, after partial absorption of the incident K_α photon, jump into the first available vacant band of the insulator, and the incident K_α becomes degraded in energy value by the amount equivalent to the gap between the so-called centre of gravity (position of maximum energy density) of the filled valence band and the centre of the first allowed vacant band of the particular insulator. That there is appreciable target penetration in the case of such elements of low atomic number has been confirmed by the appearance of a very prominent absorption edge of aluminium metal coincident with the aluminium K valence band edge while taking an emission spectra of that metal. This partial absorption of a photon is analogous to Smekal's prediction of the partial absorption of the photon by the electrons of the atom, which could not be detected for free atoms but occurs when the broad Brillouin zones of the insulators are involved.

The probability of this type of scattering seems to be large when the valence band radiation is absorbed by the valence electrons of the particular atom in which the photon originates; that is, somewhat as in the Auger process the K-valence band radiation, while coming out of the atom, becomes degraded in energy by raising the valence electron associated with the particular atom from the filled band to the next vacant allowed band.

In aluminium oxide and silica, etc., the number of parent lines involved is quite large, namely, K_α group of lines of metal ions, K_α of oxygen and K_β band of metal ions. In beryllium oxide and boron trioxide the parent lines involved are K_α of oxygen and metal ion. In diamond, however, the parent line involved is only carbon-K_α. The new type of scattering transition would probably be better detected when the involved beam is more or less monochromatic.

This type of scattering transition at once explains the origin of the long wave-length K valence band satellite of the insulators beryllium oxide, boron trioxide and diamond, and their absence in the same elements in the form of conductors which do not possess any discrete allowed and forbidden zones. The energy difference between the parent exciting radiation and the modified wave-length, that is, the difference between the K valence band peak and its long wave-length satellite, is about 7 eV. in the case of diamond, 13·4 eV. for aluminium oxide and 14·3 eV. for silica. In the case of diamond, this energy difference is determined from the ultra-violet absorption peak. The values for aluminium oxide and silica agree well with the values of the gap between the peak of the valence band and the centre of the first vacant band determined from their soft X-ray emission and absorption spectra. In the case of diamond the agreement is confirmed by: (1) the appearance of the long wave-length K_α satellite at an energy gap of 7 eV. obtained both by Siegbahn and Skinner; (2) the appearance of the ultra-violet absorption band at 7 eV.; (3) Kimball's theoretically calculated result for the distance between the filled band and the first vacant band, which also comes out to be 7 eV. In the case of beryllium oxide and boron trioxide, the energy gap between the centre of gravity of the filled band and the vacant band has not been experimentally determined; but the magnitude of their insulation properties suggests that the gap will be of the same order as that of aluminium oxide and silica, for which the experimental values are about 15 eV. The long wave-length satellites of beryllium oxide and boron trioxide also appear at a gap of about 15 eV.

Experiments on the direct scattering of a monochromatic beam in the soft X-ray region by special methods seem to give a faint indication of this new scattering. It is hoped to confirm this by further experiments and to publish the results shortly.

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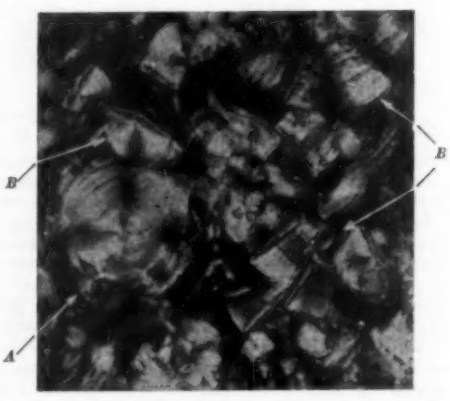
Spherulitic Sectors

During the study of soap–oil systems, a unique crystal structure has been observed having the characteristics of an incompletely formed spherulite. I have not found in the literature a description of this phenomenon, which for convenience is termed a 'spherulitic sector'.

The system in which the phenomenon was observed contained some 19 per cent of sodium soap dispersed in an acid-refined petroleum oil. The polarizing microscope revealed clusters of small elongated crystals; but after slow, static cooling from 200° C. at a rate of less than 1° C. per min. in an enclosed cell, the field appeared as in the accompanying photograph. Among shapeless masses of crystalline material were seen a number of spherulites (A) up to about 200 μ in diameter together with 'spherulitic sectors' (B). 'Spherulitic sectors', which are coloured in white light, have optical properties similar to spherulites; for example, the characteristic black crosses parallel to the planes of the nicols, which



Spherulitic structures in a soap–oil system (crossed nicols; magnification, × 130)

remain parallel on rotation of the specimen, can be clearly seen in the photograph. These interference figures have been observed to subtend various angles up to 180°, but none has been seen with a re-entrant angle. Along their radial boundaries they exhibit narrow regions of a higher-order interference colour, these regions indicating an arrangement of soap molecules different from the radial array in the intermediate zones. Cessation of growth of the spherulite may be a direct result of this arrangement at the edges.

I acknowledge the helpful discussions with Mrs. E. V. Garner and Dr. J. B. Matthews, and wish to thank Messrs. "Shell" Refining and Marketing Co., Ltd., for permission to publish this account.

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A Radiation-absorbing Centre in a Non-statical Homogeneous Universe

WHILE studying various problems connected with the birth and later evolutionary stages of stars in the scheme of general relativity, situations are encountered where an infinite spherical distribution of matter suddenly collapses and forms a spherical distribution of finite radius which starts absorbing radiation. Such a 'dark nebula' absorbing radiation cannot be surrounded by an isolated gravitational field tending to flat space-time at large distances because there is nothing in the empty space beyond to supply the energy which it absorbs. We have found spherically symmetric distributions of the form

$$ds^2 = -e^{\alpha}dr^2 - e^{\beta}r^2\,(d\theta^2+\sin^2\theta d\varphi^2) + e^{\gamma}dt^2, \quad (1)$$

which represent fields of radiation flowing inwards towards the centre and which are such that, at any time t as $r \to \infty$, the line-element (1) goes off continuously to

$$ds^2 = dt^2 - e^{\nu(t)}\,[(1-r^2/R^2)^{-1}\,dr^2 + r^2(d\theta^2 + \sin^2\theta d\varphi^2)], \quad (2)$$

so that the source of the energy which the distribution absorbs is the cosmos; and we have the field representing the flow of cosmic radiation. One such line-element is given by

$$e^{\alpha} = e^{\mu}\,.\,e^{\nu(t)}\,.\,(1-r^2/R^2)^{-1}, \quad e^{\beta} = e^{\mu}\,.\,e^{\nu(t)}, \quad e^{\gamma} = 1; \quad (3)$$
$$\mu = \mu(m,r); \quad m = m(r,t).$$

Equations to determine μ and m are

$$\frac{\partial}{\delta r}\left[\frac{1}{rm'}\frac{\partial \mu}{\partial r}\right] - \frac{1}{r}\frac{\partial}{\partial m}\left[m'\frac{\partial \mu}{\partial m}\right] - \frac{1}{r^2}\frac{\partial \mu}{\partial m} = 0; \quad (4)$$

$$(e^{-\alpha/2}\,.\,\partial m/\partial r) - (\partial m/\partial t) = 0. \quad (5)$$

It will be found that $m' = \partial m/\partial r$ will be expressible as a function of m and r only. The energy tensor is of the form

$$T^{\mu\nu} = (p + \rho)\,v^{\mu}v^{\nu} - pg^{\mu\nu} + \sigma w^{\mu}w^{\nu}. \quad (6)$$

The first two terms represent the material contents of the smoothed-out universe with

$$v^1 = v^2 = v^3 = 0; \quad v^4 = 1; \quad (v^{\mu})_{\nu}\,v^{\nu} = 0. \quad (7)$$

The last term gives the inflow of radiation[1,2],

$$w^1 < 0; \quad w^2 = w^3 = 0; \quad w_{\mu}u^{\mu} = 0; \quad (u^{\mu})_{\nu}\,w^{\nu} = 0; \quad (8)$$

and σ is the energy density of the radiation.

Conditions (7) are satisfied by choosing[3] $\gamma = 0$. The equation of continuity takes the form

$$(\sigma w^{\nu})_{\nu}\,w_1 - \partial p/\partial r = 0. \quad (9)$$

There is one field equation:

$$T_1^1 - T_2^2 = -e^{-\alpha/2}\,T_1^4, \quad (10)$$

which is satisfied in virtue of (4) and (5). m is conserved along a world-line of flow of radiation, and at large distances from the centre

$$e^{\mu} \sim 1 + \frac{\varphi(m)}{r}, \ \varphi(m) \text{ being arbitrary.} \quad (11)$$

Expressions for p, ρ, σ can be worked out.

Complete solutions with cosmogonical applications will be published elsewhere.

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Sieves of Eratosthenes

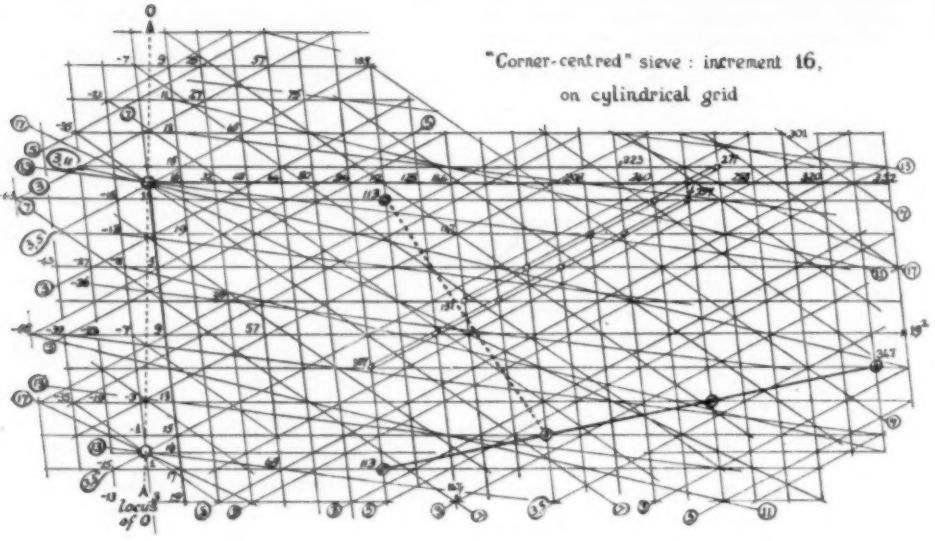
THE sieve of Eratosthenes has been used mainly for the determination of prime numbers—a function now presumably archaic. Sieves have other uses, including the finding of primes in arithmetical progression.

Series of primes, such as those listed at the end of this communication, can be found on any sieve providing certain conventions are observed. On the sieves of Fisher[1] or Dantzig[2] the series are not obvious. Series are most easily found when the increment n (100 in Fisher's sieve) is equal to, or approximates to, the common difference d of the progression.

A series is recognized by its forming a straight line of equally spaced row-column intersections. If $n = d$ or $d \pm 2$, the line can be most easily picked out: being horizontal or at 45° respectively (on a rectangular sieve).

I am not very familiar with the literature of sieves or with the theory of primes, but I think that preoccupation with sieves having $n = 100$ or higher powers of 10 may have led to the existence of series being overlooked. Series of three and four terms are numerous, as might be expected; but the number of series of five and six terms (pentads and hexads) among integers up to about 2,000 (the limit of my search) seems relatively large. In all series so far found, d is a multiple of 6, and it is believed that series of more than six primes in arithmetical progression cannot exist.

It has been found possible to construct several types of sieve, all of which are special cases of distinction within and among the continuum of numbers. The classical 'limited' sieve which theoretically extends to infinity in only one direction (say, to the right, as in Fisher's) can be extended in all directions; and a straight line which passes through and eliminates multiples of a given prime from one part of the sieve has, when produced, the same properties everywhere. The region to the left of the lowest-numbered



column—more accurately, to the left of the locus of zero—may be regarded as negative. Each sieve has an infinite number of zeros; but if only one or both the 'corner' zeros nearest to 1 and n at the top and bottom of the first column are taken into account, then it is possible to adopt a virtually systematic construction for the lines of prime multiples by taking advantage of the fact that 0 has all numbers for a factor, and by drawing lines from 0 through convenient multiples of each prime in succession. By counting the columns traversed by such lines of prime multiples on a 'centred' or Fisher sieve, it is easy to ascertain how many parallels are needed to eliminate all multiples of each prime. The simplest lines of multiples of the primes of n are horizontal.

Fisher's or Dantzig's sieve may be called rectangular, because the rows and columns are at 90°. If the columns are suitably set (at $\tan^{-1} 1/n$ to the rows) the sieve becomes cylindrical, in that the sieve can be wrapped around a cylinder so that the columns, and the lines of prime multiples, form spirals. In a cylindrical sieve, however, the loci are at 90° to the rows, whereas in a 'rectangular' sieve the loci are at $\tan^{-1} 1/n$ to the rows. These hints may sufficiently indicate the interrelationships between sieves, and also the importance of the increment n for the sieve—or, as I prefer to say, for the grid upon which the sieve is constructed.

The accompanying illustration is a composite one giving a fragment of an extended 'corner-centred' cylindrical sieve with $n = 16$, and showing a pentad and a hexad ($d = 30$). There is also a tetrad ($d = 78$), which, as the thick dotted line indicates, would not be fully recognizable as a straight line (that is, as a series of more than three primes) on a 'limited' sieve: this exemplifies the value of extension of the grid. A few numerical values are inserted for guidance.

Series of more than four terms so far found include those of which the lowest terms are given below:

d	30	60	90	16	120
Pentads	37, 151, 277	43	83	5	29, 107, 379, 743, 757
Hexads	107, 359	11, 53	—	—	−167, 239, 281, 701

The same series exist with opposite signs, the distributions being 'mirror-imaged'; but only one pair has been found having both negative and positive primes.

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Passage of Phosphorus-32 from Dried Yeast into Amphibian Gastrula Ectoderm

BRACHET[1] has suggested that an important part is played by ribonucleoproteins or their breakdown products in the evocation of neural tissue in the Amphibian gastrula both by the natural organiser and by dead or cytolysing tissues. An experiment has therefore been made in which nucleoprotein incorporating phosphorus-32 was placed in contact with gastrula ectoderm, and a determination made to see whether the radioactive isotope passed across into the ectodermal cells. In the preliminary experiment, baker's yeast was grown in a medium containing phosphorus-32; the yeast was removed by filtration, washed with water, dried at 140° C., washed again with water, and implanted into the blastocœls of *Triturus alpestris* gastrulæ either as a dry powder or after incorporation into a jelly of coagulated egg albumen. After two days, or longer, the ectoderm overlying the implant was dissected off, carefully washed free of adhering particles, and placed in a Geiger counter; the implant was treated similarly. The number of ionizations produced by single ectoderms was in some, though not all, cases clearly above that of the background; when several fragments of ectoderm were combined, the results were always positive, as shown in the accompanying table.

Expt. No.	Material tested	Days after implantation Fixed	Counted	Ionizations
M67A	5 ectoderms	4	4	503/5 min.
M67B	5 implants	4	4	3004/5 min.
	Blank			109, 131, 115, 124, 148, 138/5 min.
M67C	5 ectoderms	4	9	55, 53, 51, 48/min.
M67D	3 implants	4	9	117, 91, 117, 101, 103/min.
M68C	7 ectoderms	2	7	29, 30, 39, 37, 41/min.
M68D	5 implants	2	7	74, 82/min.
	Blank			20, 16, 18, 14/min.

This makes it clear that the phosphorus-32 is taken up by the gastrula ectoderm. It is, of course, not at all certain that all the phosphorus-32 in the dried yeast is incorporated into nucleoprotein; and even if purified nucleoprotein implants had been made, it would be possible that these would be degraded and that the phosphorus-32 is in the form of phosphate ion at the time it actually makes the passage into the ectodermal cells. It would seem impossible, by the use of labelled phosphorus alone, to determine whether nucleoprotein as such can pass into the ectoderm. The experiments have therefore been discontinued; they would have been crucial only if it had been found that phosphorus-32 was not taken up from dried yeast.

I wish to thank Mr. F. H. Krenz, of the Department of Natural Philosophy, University of Edinburgh, for carrying out the counter determinations.

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Effect of Bee Venom on Colchicine-induced Tumours

I HAVE shown that colchicine can act both as an oncogenic[1] and oncolytic[2] agent when administered to plants. Analogous effects were reported in animals by Harde[3] and by me[4] as regards the oncogenic influence of the drug, while Dustin[5] and his school have demonstrated encouraging carcinolytic effects. The nuclear anomalies[6], the stathmokinetic[7], polyploidizing[8,9] and mutagenic[4,9] as well as hormonal[6,10] responses induced by the alkaloid are equally well known. The narrow margin between its healing and toxic effects[11], however, including the risk of its oncogenic action, continues to be a serious obstacle to the application of the drug in human cancer therapy.

The reported sterilization of the pollen collected by bees on their arrival at the bee hive[12], including the blocking of the emission of the pollen tube, as confirmed by Baldensperger[13], suggested to me that the substance or substances presumably responsible for this inactivation might be a growth-inhibiting agent with similar antagonistic action on colchicine-induced tumours to those already tried[4,14]. Pending the identification of the secretion producing pollen sterilization, I have used for preliminary trials bee venom, several constituents of which are present in their other secretions and body fluids.

Commercial bee venom ('Apicine', Veleda, St. Louis, France) was used, each 1-c.c. ampoule of which contained *c.* 0·030 mgm. of venom dissolved in a physiological solution of sodium chloride. The colchicine ('Colchineos', Houdé, Paris) was supplied in 3-c.c. ampoules containing 3 mgm. of the substance dissolved as above.

Seeds of tomato (var. Ailsa Craig) and of wheat (var. Vilmorin 27) were sprouted in Petri dishes on filter paper wetted with dilutions of the above preparations as follows: group 1 received colchicine (1 : 4,000) alone; group 2, bee venom (1 : 7,500) alone; group 3, a mixture of the two substances in the same concentrations and the same proportion; and group 4, serving as controls, tap water containing the same amount of sodium chloride (2 : 1,000) as the above dilutions. Four experiments each lasting about eighteen days were carried out, in the course of which about a thousand seedlings were treated. The total amount of colchicine administered to each of the respective groups during each of the four experiments was 1·6 mgm., and that of the bee venom 0·6 mgm.

Table 1

Plants	Rate of germination (%)				Average height of shoots (mm.)				Average length of roots (mm.)			
	1	2	3	4	1	2	3	4	1	2	3	4
Tomato	85	85	95	90	14	12	18	37	4	4	7	32
Wheat*	87	85	85	96	52	170	71	215	8	44	16	111

Table 2

Plants	No. of tumours per 100 plants		Growth coefficient				Reduction of growth coeff. by venom (%)	Reduction of No. of colch. tumours by venom (%)
	1	3	1	2	3	4		
Tomato			17	17	21	35	52	
Roots	82	26						69
Total	82	26						69
Wheat*			32	79	40	123	36	
Roots	283	151						47
Shoots	50	11						78
Total	333	162						av. 62

1, colchicine treatment; 2, bee venom; 3, bee venom plus colchicine; 4, controls.
* Average of three experiments.

Tables 1 and 2 show some of the results recorded at the end of the experiments. At the beginning, the venom administered alone delayed markedly the germination of tomato; venom and colchicine speeded up germination considerably as compared with colchicine administered alone and even the water controls. A similar paradoxical stimulation of the growth of the shoots and roots was observed under the influence of the combined treatment. Later on, as a consequence of the toxic effects of the drug on the roots, this stimulation decreased gradually.

The reactions of the wheat to the venom were different; for, although when administered alone it inhibited growth processes much less than in tomato, its compensating effects on the depression of growth-rate induced by colchicine were much less marked.

Table 2 shows that the antiblastic influence of the venom was considerable on the tomato roots, which, as is known, are the only organs of these plants which react to the oncogenic action of colchicine administered via the roots.

In wheat, the reduction of tumour incidence was even more marked than would appear from the final results recorded in Table 2, for the appearance of the tumours was also considerably delayed by the venom. In consequence of this delay, the number of root tumours was, in the course of the first half-period of the experiments, up to 60 and that of the

shoots up to 650 per cent below that of the plants treated with colchicine alone. Table 2 also shows that the inhibition of the various growth-processes of the plants, as expressed by their growth coefficient, was less marked than the antiblastic effects of the venom. This indicates a differential sensitivity of the normal and pathological tissues to the drug, as postulated for all agents presumed to be carcinolytic.

Preliminary trials (unpublished) in search of the active principle of the venom have resulted only in the finding that among its alleged constituents tryptophane and choline were practically inactive in reducing colchicine-induced tumours, while palmitic acid had marked therapeutic effects on the induced phytocarcinomata of the tomato. Experiments are being carried out to test the effects of bee venom on these last as well as on their causative agent, *Phytomonas tumefaciens*.

While concluding the present experiments, my attention was directed to a note[15] reporting the reduction of tumour incidence in mice, obtained by Robinson by feeding the animals with pollen stored by the bees in the hive. Fresh pollen had apparently no such effects.

Further research is necessary to identify the various factors in each of these converging actions, and to determine whether the active principle of the substance, or substances, responsible for the inactivation of the pollen, the reduction of colchicine-induced tumours and the carcinolytic effects in mice is identical in each case.

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Methionine Content of Cereals and Legumes

The methionine content of cereals and legumes widely used in India has been measured. Determinations were made with a Lumetron photo-electric colorimeter using the sodium nitroprusside method of McCarthy and Sullivan[1] as modified by Csonka and Denton[2], and further modified by us[3]. The values shown in the accompanying table give the mean of at least two determinations. It is seen that the vetch pea is very poor in methionine content. The relationship between this very low methionine content of the vetch pea and lathyrism has been discussed elsewhere. There is evidence to support our view that lathyrism is due to absolute methionine deficiency, aided by some toxic substance which further brings about a disturbance in methionine metabolism. It is also apparent that the low nutritive value of lentil protein is due not to cystine deficiency but to methionine deficiency. The better quality of rice protein is due, at least in part, to the much higher methionine content of the former. Further investigation is in progress.

Name	Methionine contents (% in sample)
Rice (*Oryza sativa*)	0·21
Wheat (*Triticum vulgare*)	0·08
Maize (*Zea mays*)	0·08
Green gram (*Phaseolus radiatus* Linn.)	0·26
Bengal gram (*Cicer arietinum*)	0·24
Lentil (*Lens esculenta*)	0·07
Vetch pea (*Lathyrus sativus*)	0·06
Red gram (*Cajanus indicus*)	0·15

This work was carried out under the auspices of the Bihar Board of Medical Research.

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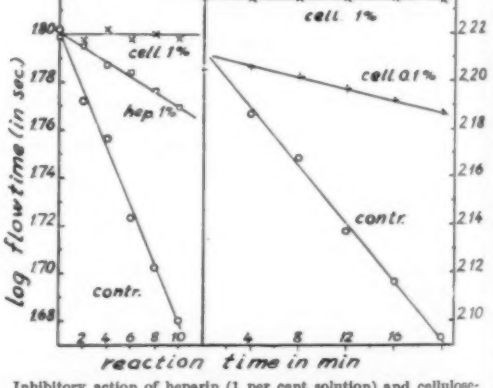
Polysaccharide Polysulphuric Acids as Antihyaluronidases

During an investigation of the antiproteolytic properties of polysaccharide polysulphuric acids, including heparin, the action of these substances was tested on hyaluronidase, as representing a depolymerizing enzyme differing from the proteolytic enzymes. The viscosity determinations were carried out as described by Lundquist[1]. They were recorded with the logarithm of the time of flow (in sec.) as the ordinate. The heparin was a commercial product (Løvens Kemiske Fabrik, Copenhagen) and the polysulphuric acids were prepared as previously described[2].

The test solutions had the following composition: potassium or sodium hyaluronate in buffer, 3 ml.; hyaluronidase solution, 0·5 ml.; inhibitor solution, 0·1 ml. The accompanying graph gives typical results.

Chondroitin sulphuric acid and heparin have been found to inhibit hyaluronidase[3,4]. According to our results, the inhibitory action of heparin is low as



Inhibitory action of heparin (1 per cent solution) and cellulosetrisulphuric acid (1 and 0·1 per cent solutions as sodium salts) on the depolymerization of two different samples of hyaluronic acid by hyaluronidase from bull sperm and bull testis respectively

compared with that of the synthetic substances. Cellulose-trisulphuric acid and chitin disulphuric acid show a particularly high inhibition. In view of the chemical structure of hyaluronic acid, the inhibitory action of the substances considered is interesting. As suggested by McClean[3], they appear to compete with hyaluronic acid for the enzyme, thus blocking its action on hyaluronic acid. The reaction is another example of the competitive inhibition in biological systems such as is observed in the sulphonamide–*p*-aminobenzoic acid antagonism.

Thanks are due to Dr. F. Lundquist, Copenhagen, and to Messrs. Leo, Ltd., Helsingborg, Sweden, for samples of hyaluronic acid and hyaluronidase.

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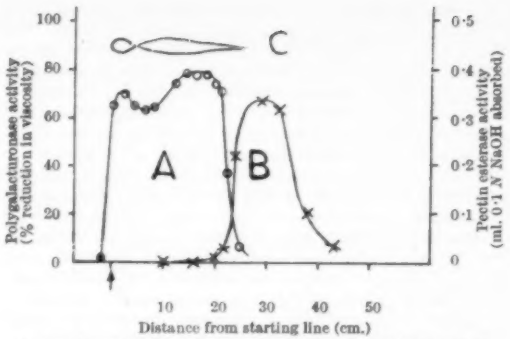
Estimation and Separation of the Pectin-Esterase and Polygalacturonase of Micro-fungi

VARIOUS methods for the estimation of pectin-esterase and polygalacturonase have been used[1,2]; but for rapid examination of cultures of micro-fungi, a modification of the 'cup-plate' diffusion method is useful. The polygalacturonase assay is carried out on a medium containing 1·5 per cent agar and 1 per cent sodium pectate at *p*H 5·0; and after incubation at 37° C. for 18 hr., the plates are sprayed with acid, when the enzyme activity is revealed as clear circular zones on an opalescent background. For the pectin-esterase assay, buffer-free agar containing 1 per cent purified pectin and methyl red adjusted to *p*H 6·0 is used, and the activity is indicated as red zones on a yellow background, due to the lowering of the *p*H by demethylation of the pectin. With each enzyme there is a linear relationship between the diameter of the zone and the logarithm of the enzyme concentration. Other enzymes (amylase, cellulase, xylanase, arabanase) may be determined similarly[3], and the activities calculated by the usual method[4,5].

Pectin-esterase and polygalacturonase have been separated by chromatography on sheets of Whatman No. 1 and No. 3 papers, using various concentrations of buffered salt solutions as developing agents. After development, the chromatograms are laid on slabs of the gel media described above to indicate the presence of pectin-esterase and polygalacturonase. Under suitable conditions the pectin-esterase travels more rapidly, and may be separated completely from the slower-moving polygalacturonase.

The area occupied by the enzyme on the chromatogram, and also the zone produced by diffusion into an agar substrate gel from the paper strip, is linearly related to the amount of enzyme applied to the paper. The activity may also be determined by dissecting duplicate strips and placing the pieces directly into tubes of the respective substrates, in which polygalacturonase is estimated by a viscometric method[6], and the pectin-esterase activity by titration[7]. This method is less sensitive than the agar-gel technique,



Paper chromatogram of a pectic enzyme preparation from a micro-fungus: (*A*) ○—○, zone of polygalacturonase activity; (*B*) ×—×—, zone of pectin-esterase activity; (*C*) tracing of polygalacturonase activity on pectic-acid – agar gel

owing to the possible overlap of zones when dissecting the paper (see graph, where the polygalacturonase activity shows two peaks), whereas on an agar-gel a duplicate strip gave clear evidence of two separate zones of activity.

With some preparations the amylase, pectin-esterase and the polygalacturonase may be resolved into two components. The pectin-esterases from different fungi differ in the total amount of de-esterification of pectin they can accomplish, and in their reaction velocities, which may be correlated with the fact that some preparations appear to have two components, and others only one.

With ammonium sulphate a gradient exists (determined by estimation in the dissected paper strip, or application of a strip to an agar-gel followed by treatment with barium chloride to indicate the concentration of sulphate ion), which *decreases* from the top of the paper down to the solvent front. Other factors, including *p*H and absorption on the cellulose, also operate.

The technique has been found useful for comparative studies on amylases and related enzymes. Recently[8], partial chromatographic separation of proteins and some enzymes has been reported, using a colorimetric technique for indicating all protein components. The two methods in combination should be useful for indicating inactive components, and overlapping enzyme activities.

Thanks are due to A. Phipps and G. L. Solomons for experimental assistance, and to the directors of this Company for permission to publish these results.

Note added in proof. With acetone–water mixtures as solvents, polygalacturonase and some amylases (β, bacterial, salivary, malt) may be resolved into two, and fungal amylase into four, components; duplicate chromatograms by the technique of Quastel and Franklin do not indicate this resolution.

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An Antibiotic, Thermophillin, from *Lenzites thermophila*

CULTURE fluids of *Lenzites thermophila* Falck 75, a Basidiomycete, were shown by Wilkins[1] to inhibit the growth of *Staph. aureus*. An antibiotic with quinonoid properties has now been isolated from the culture fluid of this fungus, which was grown at 24° C. on a 5 per cent extract of malt medium. Culture medium was kindly provided by Mrs. D. E. Gill-Carey.

The culture fluid was adjusted to *p*H 5, saturated with sodium chloride, and the active principle was then extracted with one volume of chloroform. The chloroform solution was concentrated *in vacuo*, washed with sodium carbonate solution, which removed inactive material, and chromatographed on 60/100-mesh 'Florisil' (magnesium silicate). The main active substance passed through the column on washing with chloroform. After further washing with chloroform/ethanol, acetone and aqueous acetone, which eluted inactive material, a small quantity of a second active substance was removed with phosphate buffer of *p*H 8. The latter active substance was phenolic. The fractions containing the main active substance yielded impure crystalline material on evaporation. This was rechromatographed and crystallized from ethyl acetate. The antibiotic, which has been named 'thermophillin', formed golden plates. It volatilized when heated to 245° C. and decomposed at 260° C. when heated in a sealed tube. (Found (Weiler and Strauss), C, 56·7, 57·2; H, 4·77, 4·62; OCH_3, 35·0, 35·2; $C_{14}H_8O_5(OCH_3)_4$ requires C, 57·2; H, 4·5; OCH_3, 32·8.)

Thermophillin is almost insoluble in most organic solvents, and is only very sparingly soluble in ethanol, ether and water. It is slightly soluble in chloroform.

It is rapidly destroyed in aqueous solution at room temperature at *p*H 9; but is stable at *p*H 2 and *p*H 7 on heating at 100° C. for 15 min. and at *p*H 7 on boiling for one hour.

It shows a weak activity against *Staph. aureus* when tested by the cylinder plate method. At a concentration of 1 in 10,000 it gave a zone of inhibition 15 mm. in diameter.

Thermophillin gives a yellow solution in water, which changes to red on the addition of sodium hydroxide. It liberates iodine from acid potassium iodide solution and is reduced to a colourless compound with sodium hydrosulphite. Concentrated sulphuric acid gives an immediate bright red coloration which becomes brown on heating and yellow on the addition of ethanol.

On reduction with zinc dust and warm hydrochloric acid, a colourless phenolic substance was produced which crystallized from chloroform in long colourless needles (m.p. 172° C.). These became pink on exposure to air and in a vacuum desiccator, and then rapidly darkened. This compound showed slight activity against *Staph. aureus* by the cylinder plate test. (Found, C, 56·3; H, 5·74; Act. H, 1·62; OCH_3, 34·7; $C_{19}H_{22}O_9$ requires C, 56·5; H, 5·75; and $C_{18}H_{20}O_9$ requires C, 57·0; H, 5·27 per cent.)

On acetylation with acetic anhydride and anhydrous sodium acetate, the phenolic substance yielded an acetyl derivative which separated from glacial acetic acid in the form of small needle-shaped crystals (m.p. 184° C.). This acetylated product was also obtained, though in smaller yield, by acetylation of thermophillin with acetic anhydride and sulphuric acid.

Acknowledgment is made to Miss Jean Moss for technical assistance in the course of this work.

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Plasticity of Wool

IT has already been shown that the slow extension of wool fibres under constant *stress* in water at ordinary temperatures has the characteristics of a first-order reaction; when $\log (E - E_t)$ is plotted against t, where E_t is the extension at time t, a linear relationship is obtained[1]. As the slowly extended fibres return to their original length on being released in water, even from extensions so great as 70 per cent, molecular slip is excluded, and it seemed probable that a similar, but more precise, relationship would be obtained by extending fibres under constant *load*. This deduction has been confirmed with Lincoln wool fibres in water at 22·2° C. under a load of 7×10^8 gm. per sq. cm. of the original cross-sectional area.

Although the root ends of non-medullated fibres taken from a single lock of wool were used, the slopes (k) of the lines obtained by plotting $\log (E - E_t)$ against t were found to vary from $-50{\cdot}2 \times 10^{-5}$ to $-3{\cdot}83 \times 10^{-5}$, the extensions being expressed as percentages and the time in minutes. The fibres were divided into three groups according to their rates of extension, and when a few milligrams of each type had been accumulated, their sulphur contents were determined. The results and the average values of k for the three groups are given in the accompanying table.

No. of fibres	Sulphur content (%)	k ($\times 10^{-5}$)	$C = k \times S$ ($\times 10^{-5}$)
30	3·97	− 6·0	−23·8
15	2·27	− 8·7	−19·7
18	0·98	−24·7	−24·2

If due account is taken of the difficulty of determining the sulphur content of 1·2–2·4 mgm. of wool, the product C of slope and sulphur content may be regarded as constant. The inverse relationship between the rate of extension and the sulphur content of the fibres is, of course, to be expected if the chief resistance to the unfolding of molecules in the crystalline phase is provided by cystine cross-linkages.

Similar variations in rate of extension under constant load have been observed in the case of human hair, but the value of C is different from that for Lincoln wool. It seems clear, therefore, that the plasticity of animal fibres is not determined solely by their cystine content. The influence of other factors, including the amorphous/crystalline ratio, should be capable of elucidation by classifying different types of fibre in accordance with the values of C.

Several important possibilities are revealed by these observations. Determinations of k with fibres taken from selected sites on the skin of the animal should provide the biologist with a simple micro-

method of studying the factors which influence the constitution and structure of animal fibres, and should reveal the cause of the remarkable variations in the sulphur content of fibres within a single lock. In addition, determinations of C for different types of wool may, for the first time, provide the craftsman with a measure of characteristics which he still identifies by combining a skilled tactile judgment with the results of long experience in the processing of wool.

We are indebted to the International Wool Secretariat for grants in aid of this investigation, and to Dr. G. Weiler and Dr. F. B. Strauss for the sulphur-content determinations.

O. Ripa
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July 14.

[1] Speakman, *Nature*, **159**, 338 (1947).

Behaviour of *Plasmodium berghei* in some Rodents

Plasmodium berghei Vincke and Lips 1948 is the first plasmodium found infective for rats and mice[1]. Vincke and Lips isolated this parasite from a wild tree-rat *Thamnonys* and found that it produced a fatal infection in mice and rats.

Apart from mice and rats, we have found *P. berghei* infective for the golden hamster *Mesocricetus auratus* and for the field vole *Microtus guntheri*. In the hamster *P. berghei* produces a fatal infection in almost all cases within a period of eight to twenty-nine days after inoculation. The infection is progressive, and the final parasitæmia may involve up to 50 per cent of the circulating red cells.

P. berghei is non-pathogenic for the local non-splenectomized field vole *Microtus guntheri*, in which it produces a transient patent infection involving 0·3–10 per cent and exceptionally up to 30 per cent of the red cells. The patent period lasts about a fortnight, and the infection then becomes latent except for the occasional finding of rare parasites in blood smears.

During the latent phase, parasites can be demonstrated either by inoculation of whole blood or macerated spleen or liver into susceptible animals, or by splenectomy which is generally followed by a high parasitæmia and death.

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Hebrew University,
Jerusalem.
July 3.

[1] Vincke, I. H., and Lips, M., *Ann. Soc. Belge de Méd. Trop.* (1948).

Upper Limit of Frequency for Human Hearing

The frequency above which air-borne sound becomes inaudible is generally considered to be about 20 kc./s. All sensitivity determinations agree that the threshold rises very steeply above 12 kc./s.; and above 12 kc./s. there are indications that frequency discrimination begins to fail, that is, that the least discriminable increment of frequency measured as a fraction of an octave begins to rise sharply. It seems to have been tacitly assumed that the human cochlea is incapable of response to frequencies above 20 kc./s., and that the upper limit for air-borne and bone-conducted sound is the same.

I have compared these limits on myself and two other subjects, using an oscillator of frequency variable up to 120 kc./s. and a transducer consisting of a pack of Rochelle salt plates resonant at 100 kc./s. In all cases the upper limit for air-borne sound, with the transducer held close to the external meatus of the subject, was below 16·5 kc./s. When, however, the crystal was pressed firmly on the mastoid or on the temporal region, a sound was heard for all frequencies up to at least 100 kc./s. In the former case the sound was perceived in the ipsilateral, in the latter in the contralateral ear. The failure at and above 100 kc./s. was at least partly instrumental, due to the failure of the oscillator to maintain an adequate voltage across the falling impedance of the crystal.

The sensation of pitch associated with the sound was approximately that of the highest tone audible by air conduction. As the frequency was varied continuously from 12 to 100 kc./s., the pitch rose with it to 15 kc./s. and stayed there as the frequency was further increased. No extraneous sensations, for example, of warmth, pain or discomfort, were induced and the sound heard was subjectively a perfectly normal tone.

It must be concluded: (1) that the sensory elements at the basal end of the cochlea are competent to respond to sounds up to 100 kc./s. in frequency; (2) that the failure of the normal ear to respond to air-borne sounds above 20 kc./s. is due wholly to the failure of the middle ear to transmit such frequencies.

R. J. Pumphrey

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July 11.

Anharmonicity of the Lattice Oscillations in the Alkali Halide Crystals

In my note under the above title, published in *Nature* of July 15, there are two errors to which I wish to direct attention.

(1) The oscillation discussed there, namely, of the two interpenetrating lattices of Na^+ and Cl^- ions respectively, relatively to each other, is unique among the normal modes of oscillation of the crystal in that it polarizes the medium[1]. The effect of this is to reduce the coefficient of r^2 in equation (2) from a to $a-\frac{4\pi}{3}-\frac{e^2}{8d^3}$. Equating this coefficient to $\pi^2\mu\nu_0^2$, we get the frequency ν_0, the value of which remains the same as given in the note.

(2) The coefficient f appearing in equations (4) and (5) refers to a *pair* of ions, and will be double that defined by (3). This will make the magnitude of the anharmonicity and the rate of fall of C_v with temperature twice those given in the note.

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National Physical Laboratory of India,
New Delhi.
Aug. 18.

[1] See Kellermann, *Phil. Trans. Roy. Soc.*, A, **238**, 513 (1940).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 2

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. K. A. Zandstra: "High Frequency Heating in Industry".

Tuesday, October 3

CHADWICK PUBLIC LECTURE (at the Art Gallery, Plymouth), at 4.30 p.m.—Mr. S. E. Finer: "Chadwick and the General Board of Health, 1848–1854".*

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS, LONDON CENTRE (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5 p.m.—Mr. R. G. Griffiths: "The London Station Cable and Wireless Telegraph Section, L.T.R.—an Engineering Survey".

SOCIETY OF CHEMICAL INDUSTRY, CROP PROTECTION PANEL OF THE AGRICULTURE GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. E. A. Parkin: "Biological Tests of Insecticides for Stored Products Insects".*

Wednesday, October 4

PHYSICAL SOCIETY, COLOUR GROUP (at the Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 3.30 p.m.—Mr. R. G. Horner and Mr. E. T. Purslow: "The Dependence of Anomaloscope Matching on Field Size"; Dr. E. N. Willmer: "Some Aspects of Colour Adaptation in the Central Fovea".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

Thursday, October 5

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Sir Archibald J. Gill: Inaugural Address as President.

BRITISH INSTITUTION OF RADIO ENGINEERS, NORTH-WESTERN SECTION (at the College of Technology, Manchester), at 6.45 p.m.—Dr. P. F. R. Venables: "Education in Industry".

Friday, October 6

TEXTILE INSTITUTE (at St. Mary's Parsonage, Manchester), at 1 p.m.—Mr. G. H. Jolley: "The Economics of Productivity".

ROYAL STATISTICAL SOCIETY, LONDON GROUP OF THE INDUSTRIAL APPLICATIONS SECTION (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Mr. B. Ungerson: "Statistical Problems of Personnel Management".

OIL AND COLOUR CHEMISTS' ASSOCIATION, MANCHESTER SECTION (at Cheetham Town Hall, Manchester), at 6.30 p.m.—Dr. A. S. C. Lawrence: "Topics in Colloid Chemistry". (Further Lecture on October 13.)

BRITISH PAPER AND BOARD MAKERS' ASSOCIATION, TECHNICAL SECTION, NORTHERN DIVISION (at the Engineers' Club, Albert Square, Manchester), at 7 p.m.—Dr. N. O. Clark and Mr. R. J. Booth: "Some Aspects of China Clay in Paper".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (joint meeting with the Glasgow Section, at the Royal Technical College, Glasgow), at 7.15 p.m.—Dr. E. H. Callow: "Frozen Meat".

Saturday, October 7

INSTITUTION OF CHEMICAL ENGINEERS, NORTH-WESTERN BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 3 p.m.—Prof. D. M. Newitt, F.R.S.: "Operating Conditions in High Pressure Plant".

BRITISH INTERPLANETARY SOCIETY (in the Tudor Room, Caxton Hall, Westminster, London, S.W.1), at 6 p.m.—Report on First European Astronautical Congress.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

EXPERIMENTAL OFFICERS (temporary) in the Mechanical Engineering Research Organisation, Department of Scientific and Industrial Research, (*a*) for the application of electronic techniques to the measurement of transient forces and small movements (Ref. D.48/50A), and (*b*) for fundamental research on the machinability of materials and on the physical processes involved in the cutting of metals (Ref. C.504/50A)—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (October 7).

LECTURER IN CHEMISTRY—The Principal, Acton Technical College, High Street, Acton, London, W.3 (October 7).

LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (October 7).

PSYCHOLOGIST FOR BURDEN MENTAL RESEARCH DEPARTMENT—The Secretary, 25 Albert Road, Clevedon, Somerset (October 7).

RESPONSIBLE LECTURER IN PRODUCTION ENGINEERING—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (October 7).

SENIOR EXPERIMENTAL OFFICER (unestablished), or SENIOR SCIENTIFIC OFFICER (unestablished), in the Mechanical Engineering Research Organisation, Department of Scientific and Industrial Research, to be largely responsible for the design, development and specification of measuring instruments and apparatus for a new laboratory, where basic problems of fluid mechanics and those related to flow conditions in models of pumps, etc., will be studied—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.505/50A (October 7).

LECTURER IN BIOLOGY (preferably with qualifications in physiology)—The Registrar, Nottingham and District Technical College, Shakespeare Street, Nottingham (October 9).

ASSISTANT ARCHÆOLOGY OFFICER in the Ordnance Survey Department—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 3298 (October 12).

HEADMASTER OF ROYAL HOSPITAL SCHOOL, Holbrook, Ipswich—The Director of Greenwich Hospital, Admiralty, 14 Buckingham Gate, London, S.W.1 (October 16).

LECTURER IN METALLURGY in the School of Mines and Metallurgy, University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 20).

PRINCIPAL RESEARCH OFFICER, Dairy Research Section, Melbourne—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3017 (October 21).

SENIOR LECTURER IN PHYSIOLOGY at the University of Queensland—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 23).

CHAIR OF ELECTRICAL ENGINEERING in the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Cape Town, October 30).

LECTURER IN CIVIL ENGINEERING at Canterbury University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 30).

CHAIR OF SOCIAL STUDIES in the University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 31).

LECTURER (or SENIOR LECTURER) IN GEOGRAPHY at Auckland University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 31).

READER IN PSYCHOLOGY at the University of Adelaide—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 31).

SENIOR LECTURER and LECTURER IN THE DEPARTMENT OF MATHEMATICS AND APPLIED MATHEMATICS, and a SENIOR LECTURER (Statistics), University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 31).

SENIOR LECTURER OR LECTURER IN MATHEMATICS (with special interest in geometry), in the University of Malaya—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (October 31).

LECTURER IN BIOCHEMISTRY—The Registrar, Massey Agricultural College, Palmerston North, New Zealand (November 15).

CHAIR OF PHARMACOLOGY—The Registrar, The University, Liverpool (November 18).

ASSISTANT (graduate in chemistry preferred), to undertake analytical biochemistry work in the Research Unit for Juvenile Rheumatism—The Director, Special Unit for Juvenile Rheumatism, Canadian Red Cross Memorial Hospital, Taplow, Maidenhead, Berks.

CHEMIST, preferably with agricultural experience, for research work on factors affecting digestibility—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

DEMONSTRATOR IN AGRICULTURAL CHEMISTRY at the School of Agriculture, Sutton Bonington—The Registrar, The University, Nottingham.

LECTURER IN THE DEPARTMENT OF AERONAUTICS—The Head of the Aeronautics Department, City and Guilds College, Exhibition Road, London, S.W.7.

PHYSICIST (with a degree in physics and aptitude for practical experimental work)—The Director of Research, Lace Research Association, 71 Upper Parliament Street, Nottingham.

PHYSICISTS (4) for fundamental research on the properties of matter—The Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

SCIENTIFIC OFFICERS (with honours, or equivalent, degree), for research on silage making investigations and ley utilization investigations, and ASSISTANT EXPERIMENTAL OFFICERS (with degree or similar qualification in agriculture) for research on identical twin collecting and rearing, experimental work with pigs, and experimental work on milking technique—The Secretary, National Institute for Research in Dairying, Shinfield, Reading.

SENIOR PHYSICIST—The Medical Director, Hogarth Radiotherapeutic Centre, Nottingham.

SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS in various Government Departments, and covering a wide range of scientific research and development in most of the major fields of fundamental and applied science—The Secretary, Civil Service Commission (Scientific Branch), 7th Floor, Trinidad House, Old Burlington Street, London, W.1, quoting No. 2887.

SURVEYORS to carry out topographical and cadastral surveys in Kenya—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27076/23.